SIEMENS Gamesa
RENEWABLE ENERGY

SISTEMAS ENERGÉTICOS CABEZO NEGRO S. A.

ANEXOS TOMO I

REPOTENCIACIÓN
PARQUE EÓLICO “I+D JAULÍN”

T.M. DE JAULÍN (ZARAGOZA)
Enero 2024

PROCON MANAGEMENT

PROCON MANAGEMENT, S.L.

ÍNDICE

1. ANEXO I DOCUMENTACIÓN REQUERIDA POR EL DEPARTAMENTO DE ECONOMÍA, INDUSTRIA Y EMPLEO DEL GOBIERNO DE ARAGÓN DECRETO-LEY 2/2016, DE 30 DE AGOSTO, DE MEDIDAS URGENTES PARA LA EJECUCIÓN DE LAS SENTENCIAS DICTADAS EN RELACIÓN CON LOS CONCURSOS CONVOCADOS EN EL MARCO DEL DECRETO 124/2010, DE 22 DE JUNIO, Y EL IMPULSO DE LA PRODUCCIÓN DE ENERGÍA ELÉCTRICA A PARTIR DE LA ENERGÍA EÓLICA EN ARAGÓN. ARTÍCULO 13 APARTADO C) 4

1.1. Razones de cualquier índole que justifiquen la implantación o modificación del parque eólico en la zona de que se trate. 5

1.2. Criterios técnicos de situación que desde el punto de vista de aprovechamiento del recurso eólico, optimización de la planificación de redes de evacuación y transporte eléctrico, respecto al patrimonio cultural y a los valores medioambientales se han segido para elegir los terrenos en los que se situarán concretamente las instalaciones. 6

1.3. Descripción de los recursos eólicos presentes mediante las mediciones efectuadas o un estudio o modelización que confirme la existencia de recurso suficiente para el funcionamiento del parque. 7

1.4. Adecuación del proyecto a la situación de planeamiento urbanístico vigente, en el área de implantación prevista. 8

1.5. Descripción y justificación de los datos referidos a la ordenación del parque eólico, tales como superficie, ocupación de la finca por edificaciones, instalaciones y superficies pavimentadas. Se incluirá asimismo, la justificación de los movimientos de terra a efectuar. .. 9

1.6. Descripción de los servicios existentes y previstos relativos a accesos, abastecimientos, energías, alumbrado y otras instalaciones. 10

1.7. Descripción de las características formales y constructivas; uso y destino de las edificaciones, referidas a la superficie construida; altura de las edificaciones y de los elementos singulares, composición, materiales y otras. 11

1.8. Plazo de ejecución del proyecto. 12

1.9. Presupuesto de las instalaciones. 13

1.10. Descripción detallada de todas las instalaciones de alta y baja tensión con adecuación a la Normativa Vigente. 14

1.11. Descripción de las instalaciones de evacuación de energía eléctrica hasta el punto de conexión con la red de distribución o transporte. 15

1.12. Medidas previstas de protección contra incendios. 16

1.13. Descripción del aerogenerador a instalar que certifique el cumplimiento de las exigencias del operador del sistema conforme a la normativa estatal vigente y principales características, en especial, el apartado relativo a los huecos de tensión. Declaracin de conformidad CE de las máquinas que se pretende instalar, junto con una descripción detallada del aerogenerador a instalar. 17

1.14. Adecuación de las instalaciones a las disposiciones relativas a la seguridad y a la salud para la utilización por los operadores de los equipos de trabajo. 18

1.15. Estudio de seguridad y salud 19

1.16. Relación de personas físicas y jurídicas propietarios de bienes, instalaciones, obras o servicios afectados por la instalación. 20

1.17. Partes del proyecto que afectan a bienes, instalaciones, obras o servicios, centros o zonas dependientes de otras Administraciones Públicas, Organismos, Corporaciones, o Departamentos del Gobierno de Aragón, para que estos establezcan, si procede, el condicionado procedente en el trámite de informe. 21

1.18. Documentación acreditativa de la capacidad legal, técnica y económica del solicitante. 22

1.19. Informe de las servidumbres aeronáuticas afectadas y, en caso de existir, estudio aeronáutico que asegure que las instalaciones no comprometen la seguridad de las operaciones de las aeronaves, de acuerdo con el Real Decreto 1541/2003, por el que se modifca el Decreto 584/1972, de servidumbres aeronáuticas, y el Decreto 1844/1975, de servidumbres aeronáuticas en helipuertos, para regular excepciones a los límites establecidos por las superficies limitadoras de obstáculos alrededor de aeropuertos y helipuertos. 23

1.19.1. Solicitud enviada a AESA. 23

1.20. Cuantos documentos adicionales relacionados con el expediente y relevantes para su resolución estime oportuno reclamar el órgano competente para la tramitación del expediente administrativo. 31

2. ANEXO II CARACTERISTICAS TÉCNICAS DE LOS AEROGENERADORES 32

2.1. Características y funcionamiento general de la plataforma de aerogeneradores SG 5.0 145 32

2.2. CARACTERÍSTICAS DE VIALES Y PLATAFORMAS APARA AEROGENERADORES SG 6.6 170 33

2.3. CUMPLIMIENTO DELOS CODIGOS DE RED PARA CONEXIÓN DE PARQUES EÓLICOS34

1. ANEXO I DOCUMENTACIÓN REQUERIDA POR EL DEPARTAMENTO DE ECONOMÍA, INDUSTRIA Y EMPLEO DEL GOBIERNO DE ARAGÓN DECRETO-LEY 2/2016, DE 30 DE AGOSTO, DE MEDIDAS URGENTES PARA LA EJECUCIÓN DE LAS SENTENCIAS DICTADAS EN RELACIÓN CON LOS CONCURSOS CONVOCADOS EN EL MARCO DEL DECRETO 124/2010, DE 22 DE JUNIO, Y EL IMPULSO DE LA PRODUCCIÓN DE ENERGÍA ELÉCTRICA A PARTIR DE LA ENERGÍA EÓLICA EN ARAGÓN. ARTÍCULO 13 APARTADO C)

1.1. Razones de cualquier índole que justifiquen la implantación o modificación del parque eólico en la zona de que se trate.

1 Obtener energía partiendo de recursos no contaminantes sin emisión de gases que contribuyen a aumentar el efecto invernadero, especialmente CO2.

2 Potenciar el uso de energías renovables obteniendo una mejora en el medioambiente y a su vez repercusiones positivas en el ámbito socioeconómico

3 Esta iniciativa privada de aprovechamiento de la energía eólica repercutirá directamente sobre la estructura productiva de la zona y generará unos ingresos por canon de cesión de terrenos, licencia de obras, contratación de personal e ingresos de carácter fiscal y administrativos importantes.

4 Las instalaciones mejorarán las infraestructuras de regionales energéticas.

5 El carácter inagotable de la energía eólica y su utilización que es independiente de cualquier relación comercial, hace que el desarrollo de este parque y sus infraestructuras ofrezcan un aprovechamiento óptimo de un de lo recursos naturales propios de Aragón como es el viento.

6 Contribución en la disminución de la dependencia energética de nuestro país así como de la Unión Europea.

1.2. Criterios técnicos de situación que desde el punto de vista de aprovechamiento del recurso eólico, optimización de la planificación de redes de evacuación y transporte eléctrico, respecto al patrimonio cultural y a los valores medioambientales se han seguido para elegir los terrenos en los que se situarán concretamente las instalaciones.

El parque es una repotenciación de uno existente y en funcionamiento.

1.3. Descripción de los recursos eólicos presentes mediante las mediciones efectuadas o un estudio o modelización que confirme la existencia de recurso suficiente para el funcionamiento del parque.

Ver estudio de viento incluido en el volumen ANEXOS TOMO II

1.4. Adecuación del proyecto a la situación de planeamiento urbanístico vigente, en el área de implantación prevista.

Ya existe un parque eólico en funcionamiento.

1.5. Descripción y justificación de los datos referidos a la ordenación del parque eólico, tales como superficie, ocupación de la finca por edificaciones, instalaciones y superficies pavimentadas. Se incluirá asimismo, la justificación de los movimientos de tierra a efectuar.

Tabla resumen de las afecciones del parque eólico "I+D JAULÍN"

			Superficie
Ocupación aerogeneradores			405 m2
Ocupación plataformas			6.091 m2
Ocupación caminos	Existentes	97,45%	82.226 m2
	Nuevos	2,55%	2.150 m2
	Total caminos		84.376 m2
Ocupación total			90.872 m2
Longitud Caminos	Existentes	93,20%	3.868 m
	Nuevos	6,80%	282 m
	Total caminos		4.150 m
Ocupación de las losas de cimentación de los aerogeneradores			
Ocupación aerogeneradores (Losa de cimentación)			452 m2

En el anexo de cálculos de la memoria del proyecto se han colocado las tablas con los movimientos de tierra a realizar en Caminos, Cimentaciones y Plataformas de Montaje.

En los planos 07 de perfiles longitudinales se puede observar cómo se han trazado los caminos para ajustar sus características de diseño a los condicionantes de los transportes y de las grúas de montaje, el resultado de los movimientos de tierras expresado en las tablas es consecuencia de adaptar los caminos a esos condicionantes.

En el Anexo de cálculos se incluye también una tabla con la superficie de los taludes para replantar con tierra vegetal procedente de los desbroces.

1.6. Descripción de los servicios existentes y previstos relativos a accesos, abastecimientos, energías, alumbrado y otras instalaciones.

Los viales de acceso al parque eólico ya están en uso, se adaptarán a los requisitos de los transportes.

1.7. Descripción de las características formales y constructivas; uso y destino de las edificaciones, referidas a la superficie construida; altura de las edificaciones y de los elementos singulares, composición, materiales y otras.

El uso y destino tanto de las edificaciones como los elementos singulares de este proyecto, son la generación de energía eléctrica a partir del viento.

En el parque eólico, los elementos singulares a instalar son los aerogeneradores. En la memoria del proyecto y en el ANEXO , se detalla su altura, composición y materiales.

1.8. Plazo de ejecución del proyecto.

Id	ACTIVIDAD												
	Mes	1	2	3	4	5	6	7	8	9	10	11	12
	PARQUE EOLICO												
1	Obra Civil												
2	Camino de Acceso												
3	Cimentaciones												
4	Desmantelamiento aerogeneradores												
5	Plataformas												
6	Hidrosiembra												
7	Red de media tensión												
8	Apertura de zanjas												
9	Tendido de conductores y cierre zanjas												
10	Aerogeneradores												
11	Montaje de aerogeneradores												
12	Conexión de aerogeneradores												
13	Puesta en marcha												
14	**SUBESTACION DE TRANSFORMACION**												
15	Instalacion de aparamenta												
16	Pruebas												

1.9. Presupuesto de las instalaciones.

Ver presupuesto en los documentos de Proyecto

1.10. Descripción detallada de todas las instalaciones de alta y baja tensión con adecuación a la Normativa Vigente.

El proyecto presentado visado por técnico competente y visado por el colegio oficial, cumple con los requisitos establecidos en el artículo 12 e Instrucción Técnica Complementaria ITC-RAT20, del vigente Reglamento sobre Condiciones Técnicas y Garantías de Seguridad en Centrales Eléctricas, Subestaciones y Centros de Transformación (aprobadas mediante Real Decreto 337/2014, de 9 de mayo, por el que se aprueban el Reglamento sobre condiciones técnicas y garantías de seguridad en instalaciones eléctricas de alta tensión y sus Instrucciones Técnicas Complementarias ITC-RAT 01 a 23.)

Ver Capitulo 1.3 de la memoria del proyecto

1.11. Descripción de las instalaciones de evacuación de energía eléctrica hasta el punto de conexión con la red de distribución o transporte.

El parque actual ya tiene evacuación en SET Muel y no está previsto modificar las instalaciones de enlace y evacuación.

1.12. Medidas previstas de protección contra incendios.

AEROGENERADORES

Esta instalación no está incluida dentro del ámbito de aplicación del real Decreto 2267/2004 de 3 de Diciembre por el que se aprueba el reglamento de seguridad contra incendios en los establecimientos industriales. Según se deduce del artículo 2 del citado Real Decreto y del articulo 3.1 de la Ley 21/1992 de 16 de Julio de Industria.

En la memoria se ha especificado que cada aerogenerador dispondrá de un extintor contra incendios, clase B29 en la zona de celdas. Es tos extintores cumplirán con lo indicado en la MIE RAT 14 capitulo 4, por ser los transformadores de aislamiento seco, no es necesario un sistema de extinción fijo.

Como en cualquier instalación existe un riesgo de incendio (calentamiento excesivo de la multiplicadora, de los sistemas hidráulicos etc). Los sistemas de detección de incendios instalados en el aerogenerador están conectados al SCADA del parque, por lo que garantiza la rápida actuación ante cualquier incidente.

El hecho que el sistema de generación se encuentre situado a una considerable altura del suelo permite que el incendio quede bastante aislado, con lo que se minimiza el riesgo de propagación del mismo a otras partes de la instalación.

Existe el riesgo de que se produzca un incendio cuando el personal de mantenimiento se encuentre dentro de la nacelle por lo que cada operado deberá de disponer de un sistema paracaídas que permita una rápida evacuación del aerogenerador en el caso de que se produzca un incendio incontrolado que bloquee el acceso a la escalera de la torre y sea necesario escapar por las otras salidas que dispone el aerogenerador.

El personal Operación Mantenimiento y Servicio de SIEMENS GAMESA, está entrenado para realizar esta evacuación de emergencia.

Queda totalmente prohibido el acceso de ninguna persona a la zona de altura del aerogenerador, si no va acompañado de un técnico cualificado de la compañía y deberá contar con los mismos equipos de protección y evacuación que el personal de la compañía, así como estar en posesión y en vigor, de la certificación necesaria para acceder a lo alto de un aerogenerador.

1.13. Descripción del aerogenerador a instalar que certifique el cumplimiento de las exigencias del operador del sistema conforme a la normativa estatal vigente y principales características, en especial, el apartado relativo a los huecos de tensión. Declaración de conformidad CE de las máquinas que se pretende instalar, junto con una descripción detallada del aerogenerador a instalar.

VER MEMORIA DEL PROYECTO Y ANEXO II

1.14. Adecuación de las instalaciones a las disposiciones relativas a la seguridad y a la salud para la utilización por los operadores de los equipos de trabajo.

A partir del estudio de seguridad y salud del proyecto, el contratista de la obra elaborará un Plan de Seguridad, previo al inicio de los trabajos Este plan será supervisado y aprobado por el coordinador de seguridad y salud que asuma los trabajos.

1.15. Estudio de seguridad y salud

Ver Estudio de Seguridad y Salud en los documentos de proyecto.

1.16. Relación de personas físicas y jurídicas propietarios de bienes, instalaciones, obras o servicios afectados por la instalación.

Nº FINCA PROYECTO	DATOS DE LA FINCA					AFECCIÓN										
						AEROGENERADOR				LÍNEA SUBTERRÁNEA			CAMINOS		SET
	PGNO	PARC	REF CATASTRAL	TERMINO MUNICIPAL.	SUPERFICIE PARCELA (m2)	Uds	VUELO (m2)	ZAPATA (m2)	Plataforma (m2)	Longitud (m)	Superficie Permanente (m2)	Superficie Temporal (m2)	Longitud (m)	Superficie (m2)	Superficie (m2)
46	1	1	50132A00100001	Jaulin	850.225,88	1	16.512,89	405,00	5.803,29	683,75	3.000,86	2.055,33	773,93	5.775,02	0,00
15	1	6	50132A00100006	Jaulin	125.927,99		0,00	0,00	0,00	0,00	0,00	0,00	31,88	601,24	0,00
25	1	23	50132A00100023	Jaulin	154.649,61		0,00	0,00	0,00	0,00	0,00	0,00	0,00	70,40	0,00
19	1	26	50132A00100026	Jaulin	7.264,39		0,00	0,00	0,00	0,00	0,00	0,00	179,29	1.502,30	0,00
29	1	38	50132A00100029	Jaulin	16.341,98		0,00	0,00	0,00	0,00	0,00	0,00	0,00	281,23	0,00
31	1	31	50132A00100031	Jaulin	26.089,67		0,00	0,00	0,00	0,00	0,00	0,00	0,00	114,42	0,00
32	1	32	50132A00100032	Jaulin	11.212,45		0,00	0,00	0,00	0,00	0,00	0,00	0,00	52,38	0,00
34	1	34	50132A00100034	Jaulin	7.749,18		0,00	0,00	0,00	0,00	0,00	0,00	0,00	98,10	0,00
36	1	36	50132A00100036	Jaulin	8.745,37		0,00	0,00	0,00	0,00	0,00	0,00	19,22	395,41	0,00
37	1	37	50132A00100037	Jaulin	2.766,16		0,00	0,00	0,00	0,00	0,00	0,00	191,11	1.171,85	0,00
27	1	38	50132A00100038	Jaulin	21.006,91		0,00	0,00	0,00	0,00	0,00	0,00	0,00	105,59	0,00
14	15	1	50132A01500001	Jaulin	1.842,71		0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,18	0,00
17	15	170	50132A01500170	Jaulin	32.906,72		0,00	0,00	0,00	0,00	0,00	0,00	0,00	74,59	0,00
44	17	2	50132A01700002	Jaulin	3.251,90		0,00	0,00	0,00	0,00	0,00	0,00	28,90	337,25	0,00
42	17	3	50132A01700003	Jaulin	9.189,25		0,00	0,00	0,00	0,00	0,00	0,00	0,00	47,40	0,00
41	17	4	50132A01700004	Jaulin	24.942,10		0,00	0,00	0,00	0,00	0,00	0,00	32,50	444,12	0,00
40	17	6	50132A01700006	Jaulin	14.971,57		0,00	0,00	0,00	0,00	0,00	0,00	5,87	269,07	0,00
39	17	13	50132A01700013	Jaulin	19.745,29		0,00	0,00	0,00	0,00	0,00	0,00	0,00	227,50	0,00
38	17	14	50132A01700014	Jaulin	11.911,27		0,00	0,00	0,00	0,00	0,00	0,00	152,24	1.052,67	0,00
45	17	24	50132A01700024	Jaulin	644.721,61		0,00	0,00	0,00	149,04	344,77	427,05	770,03	8.910,34	0,00
30	17	53	50132A01700053	Jaulin	5.107,99		0,00	0,00	0,00	0,00	0,00	0,00	6,25	486,71	0,00
33	17	56	50132A01700056	Jaulin	217.384,70		0,00	0,00	0,00	0,00	0,00	0,00	272,33	1.918,44	0,00
28	17	60	50132A01700060	Jaulin	7.239,47		0,00	0,00	0,00	0,00	0,00	0,00	79,92	352,39	0,00
24	17	65	50132A01700065	Jaulin	33.431,27		0,00	0,00	0,00	0,00	0,00	0,00	580,73	4.330,85	0,00
26	17	73	50132A01700073	Jaulin	8.734,17		0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,51	0,00
2	18	9	50132A01800009	Jaulin	6.060,01		0,00	0,00	0,00	0,00	0,00	0,00	0,22	314,59	0,00
1	18	10	50132A01800010	Jaulin	10.518,36		0,00	0,00	0,00	0,00	0,00	0,00	6,27	200,27	0,00
11	18	134	50132A01800143	Jaulin	4.367,03		0,00	0,00	0,00	0,00	0,00	0,00	3,40	215,69	0,00
3	19	3	50132A01900003	Jaulin	3.209,06		0,00	0,00	0,00	0,00	0,00	0,00	0,00	96,34	0,00
4	19	5	50132A01900004	Jaulin	3.069,96		0,00	0,00	0,00	0,00	0,00	0,00	49,00	811,96	0,00

1.17. Partes del proyecto que afectan a bienes, instalaciones, obras o servicios, centros o zonas dependientes de otras Administraciones Públicas, Organismos, Corporaciones, o Departamentos del Gobierno de Aragón, para que estos establezcan, si procede, el condicionado procedente en el trámite de informe.

Nº FINCA PROYECTO	DATOS DE LA FINCA					AFECCIÓN									
						AEROGENERADOR				LÍNEA SUBTERRÁNEA			CAMINOS		SET
	PGNO	PARC	REF CATASTRAL	TERMINO MUNICIPAL.	SUPERFICIE PARCELA (m2)	Uds	VUELO (m2)	ZAPATA (m2)	Plataforma (m2)	Longitud (m)	Superficie Permanente (m2)	Superficie Temporal (m2)	Longitud (m)	Superficie (m2)	Superficie (m2)
18	1	9002	50132A00109002	Jaulin	4.162,61		0,00	0,00	0,00	0,00	0,00	0,00	0,00	11,81	0,00
16	1	9003	50132A00109003	Jaulin	1.103,03		0,00	0,00	0,00	0,00	0,00	0,00	270,87	1.053,48	0,00
21	1	9004	50132A00109004	Jaulin	3.419,05		0,00	0,00	0,00	1,18	2,07	2,64	118,86	1.732,12	0,00
35	1	9005	50132A00109005	Jaulin	171,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,00
13	15	9001	50132A01509001	Jaulin	5.024,33		0,00	0,00	0,00	0,00	0,00	0,00	97,06	993,74	0,00
22	17	9001	50132A01709001	Jaulin	3.662,48		0,00	0,00	0,00	1,50	2,59	4,46	333,96	1.976,11	0,00
23	17	9002	50132A01709002	Jaulin	5.534,85		0,00	0,00	0,00	0,00	0,00	0,00	4,48	52,23	0,00
43	17	9003	50132A01709003	Jaulin	773,70		0,00	0,00	0,00	0,00	0,00	0,00	6,25	308,76	0,00
12	18	9002	50132A01809002	Jaulin	2.259,00		0,00	0,00	0,00	0,00	0,00	0,00	60,09	269,16	0,00
10	18	9007	50132A01809007	Jaulin	14.612,01		0,00	0,00	0,00	0,00	0,00	0,00	0,00	10,71	0,00
7	19	9011	50132A01909005	Jaulin	219,95		0,00	0,00	0,00	0,00	0,00	0,00	0,22	22,22	0,00
9	19	9009	50132A01909009	Jaulin	9.112,11		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00
5	19	9010	50132A01909010	Jaulin	85,88		0,00	0,00	0,00	0,00	0,00	0,00	2,78	21,43	0,00

1.18. Documentación acreditativa de la capacidad legal, técnica y económica del solicitante.

SE HA INCLUIDO EN EL ANEXO II

1.19. Informe de las servidumbres aeronáuticas afectadas y, en caso de existir, estudio aeronáutico que asegure que las instalaciones no comprometen la seguridad de las operaciones de las aeronaves, de acuerdo con el Real Decreto 1541/2003, por el que se modifica el Decreto 584/1972, de servidumbres aeronáuticas, y el Decreto 1844/1975, de servidumbres aeronáuticas en helipuertos, para regular excepciones a los límites establecidos por las superficies limitadoras de obstáculos alrededor de aeropuertos y helipuertos.

Solicitud enviada a AESA.

MINISTERIO
DE TRANSPORTES
Y MOVILIDAD SOSTENIBLE

AESA AGENCIA ESTATAL DE SEGURIDAD AÉREA

ENTRADA
Registro General AESA
Número: 2024020234
Fecha: 30/01/2024 10:13

JUSTIFICANTE DE PRESENTACIÓN DE REGISTRO

1. DATOS DE LOS SOLICITANTES

SISTEMAS ENERGÉTICOS CABEZO NEGRO, SAU (A99141913) representado por MICHAEL MATROSS NOBANDIANS (X9637577W)

2. ASUNTO

SOLICITUD DE EVALUACION DE SSAA
SOLICITUD DE EVALUACION DE ACTUACION EN CERCANIAS AFECTADAS POR ZONAS DE SERVIDUMBRES AERONAUTICAS CON ORIGEN O DESTINO EN ESPAÑA

PASEO DE LA CASTELLANA, 112
28046, MADRID
TEL: 91 396 80 00

MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE

SOLICITUD PARA LA TRAMITACIÓN DE SERVIDUMBRES AERONÁUTICAS

AESA AGENCIA ESTATAL DE SEGURIDAD AÉREA

DIRECCIÓN DE SEGURIDAD DE AEROPUERTOS Y NAVEGACIÓN AÉREA

SERVIDUMBRES AERONÁUTICAS

1. PETICIONARIO

1. CIF: A99141913		2. Razón Social: SISTEMAS ENERGÉTICOS CABEZO NEGRO, SAU				
3. Tipo Vía: Calle	4. Domicilio Social: Ramírez de Arellano	5. Número: 37	6. Escalera:	7. Piso:	8. Puerta:	9. Código Postal: 28043
10. Municipio: Madrid		11. Provincia: Madrid				
12. Teléfono: 664032997		13. Correo Electrónico: alejandro.ribera@siemensgamesa.com				

2. REPRESENTANTE DEL PETICIONARIO

14. NIF: X9637577W	15. Apellidos y Nombre: MATROSS NOBANDIANS MICHAEL
16. Télefono:	17. Correo Electrónico: michael.matross@siemensgamesa.com

3. DATOS DE LA SOLICITUD

18. Tipo de la Solicitud: Autorización	19. Código de la solicitud: S24-1045

4. TIPOS DE ACTUACIÓN

20. Id	1				
21. Municipio	Jaulín	22. Provincia	Zaragoza	23. Datum	ETRS89
24. Huso	30	25. UTM X	665230,00	26.UTM Y	4590692,00
27. Altura solicitada (m.)	200,00	28. Cota terreno (m.s.n.m)	651,00	29. Altura cubierta (m)	
30. Uso	Parque eólico	31. Carácter de uso	Permanente		
32. Descripción	Modificación de las coordenadas de las turbinas con Autorización				
20. Id	2				
21. Municipio	Jaulín	22. Provincia	Zaragoza	23. Datum	ETRS89
24. Huso	30	25. UTM X	664987,00	26.UTM Y	4590052,00
27. Altura solicitada (m.)	200,00	28. Cota terreno (m.s.n.m)	648,00	29. Altura cubierta (m)	
30. Uso	Parque eólico	31. Carácter de uso	Permanente		
32. Descripción	Modificación de las coordenadas de las turbinas con Autorización				

5. MEDIOS AUXILIARES

33. Id	1Aux				
34. Municipio	Jaulín	35. Provincia	Zaragoza	36. Datum	ETRS89
37. Huso	30	38. UTM X	664987,00	39.UTM Y	4590052,00
40. Altura solicitada (m.)	140,00	41. Cota terreno (m.s.n.m)	648,00	42. Tiempo estimado	3 meses
43. Tipo medio	Grúa móvil	44. Carácter de uso	40		

Ejemplar para el interesado

CORREO ELECTRONICO
servidumbres.aesa@seguridadaerea.es

www.seguridadaerea.gob.es

PASEO DE LA CASTELLANA, 112
28046 MADRID
TEL: +34 91 396 8320
FAX: +34 91 770 5459

45. Descripción	Grúa

6. OBSERVACIONES

46. Observaciones

7. DOCUMENTACIÓN ADICIONAL

47. Descripción	48. Nombre del documento	49. Huella
Plano(s) de situación a escala	20240130101156-Plano situacion.pdf	54fa8c7a18b427c689a970460d8e2969
Plano(s) de situación a escala	20240130101201-Plano situacion.pdf	6028d9a541ee76d7046df70fff860a10
Plano(s) acotado(s) de la planta y el alzado	20240130101208-Plano planta.pdf	3d5933cbbc457c8c1b2ad034472877f8
Plano(s) acotado(s) de la planta y el alzado	20240130101214-Plano planta.pdf	36d9d3bed120fc4e133150c51096ab56
En caso de representante, poder notarial o similar que lo acredite.	20240130101240-Poder notarial.pdf	4dfc3acb2240b379bdd53c84009181ad

8. FECHA Y FIRMA

En Madrid
a 30 de enero de 2024

Firma:

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MINISTERIO
DE TRANSPORTES
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AGENCIA ESTATAL
DE SEGURIDAD AÉREA

La Agencia Estatal de Seguridad Aérea (En adelante AESA), como Responsable del Tratamiento de sus datos personales en cumplimiento *de la Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales y el Reglamento (UE) 2016/679 del Parlamento Europeo y del Consejo, de 27 de abril de 2016, relativo a la protección de las personas físicas en lo que respecta al tratamiento de datos personales y a la libre circulación de estos datos (Reglamento General de Protección de Datos)*, le informa, de manera explícita e inequívoca, que se va a proceder al tratamiento de sus datos de carácter personal obtenidos del "Formulario de solicitud para la tramitación de servidumbres aeronáuticas y obstáculos mayores de 100 m", para el tratamiento "***Autorización en materia de servidumbres aeronáuticas***" y con la finalidad:

- De ***"Gestionar autorizaciones".*** El usuario no podrá negar su consentimiento por ser este una obligación legal, definida por la ***"Ley 48/1960, de 21 de julio, sobre Navegación Aérea."***

Este tratamiento de datos de carácter personal se encuentra incluido en el Registro de Datos Personales de AESA.

La legalidad del tratamiento está basada en una obligación legal.

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La categoría de los datos de carácter personal que se tratan son únicamente ***"Datos identificativos (nombre, DNI, dirección, correo-e...)".***

De acuerdo con lo previsto en la citada *Ley Orgánica de Protección de Datos y Garantías de Derechos Digitales* y el también citado *Reglamento General de Protección de Datos*, puede ejercitar sus derechos de Acceso, Rectificación, Supresión, Portabilidad de sus datos, la Limitación u Oposición a su tratamiento ante el Delegado de Protección de Datos, dirigiendo una comunicación al correo dpd.aesa@seguridadaerea.es

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https://www.seguridadaerea.gob.es/es/quienes-somos/normativa-aesa/proteccion-de-datos

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Autorización	S24-1045

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AGENCIA ESTATAL
DE SEGURIDAD AÉREA

1.20. Cuantos documentos adicionales relacionados con el expediente y relevantes para su resolución estime oportuno reclamar el órgano competente para la tramitación del expediente administrativo.

2. ANEXO II CARACTERISTICAS TÉCNICAS DE LOS AEROGENERADORES

2.1. Características y funcionamiento general de la plataforma de aerogeneradores SG 5.0 145

Developer package SG 5.0-145

Document ID and revision	Status	Status date (yyyy-mm-dd)	Language
GD477725 R7	Released	2023-08-01	en-US

Original or translation of
Original

File name
GD477725 R7.docx

Siemens Gamesa Renewable Energy S.A. Parque Tecnológico de Bizkaia, Edificio 222, 48170, Zamudio, Vizcaya, Spain
+34 944 03 73 52 – info@siemensgamesa.com – www.siemensgamesa.com

Application of the Developer Package

The Developer Package serves the purpose of informing customers about the latest planned product development from Siemens Gamesa Renewable Energy (SGRE). By sharing information about coming developments, SGRE can ensure that customers are provided with necessary information to make decisions.

Furthermore, the Developer Package can assist in guiding prospective customers with the indicated technical footprint of the SG 5.0-145 in cases where financial institutes, governing bodies, or permitting entities require product specific information in their decision processes.

All technical data contained in the Developer Package is subject to change owing to ongoing technical developments. Information contained within the Developer Package may not be treated separately or out of the context of the Developer Package.

The information contained in the Developer Package may not be used as legally binding documentation and cannot be used in contracts between SGRE and any other parties. This Developer Package contains preliminary technical data on SGRE turbines currently under development and can be used in an indicative capacity only.

All technical data is subject to change according to the technical development of the wind turbine.

Developer Package
SG 5.0-145

Table of contents

Introduction 5
Technical Description 6
Nacelle Arrangement 9
Nacelle Dimensions 10
Elevation Drawing 11
Blade Drawing 12
Design Climatic Conditions 13
Standard Power Curve, Standard power operational mode 15
Standard Ct Curve, Standard power operational mode 17
Power Curve, Air density, Standard power operational mode 18
Ct Curve, Air Density, Standard power operational mode 20
Standard Acoustic Emission 21
Noise Reduction System (NRS) operational modes 22
Electrical Specifications 28
Simplified Single Line Diagram 29
Transformer Specifications ECO 20 kV* 30
Transformer Specifications 34.5 kV* 30
Switchgear Specification 31
Preliminary Foundation Loads 32
Tower Dimensions 33
Estimated Foundation Design 37
Preliminary Grid Performance Specification, 50 Hz 44
Preliminary Grid Performance Specification, 60 Hz 47
Reactive Power Capability, 50 Hz 50
Reactive Power Capability, 60 Hz 53
SCADA, System Description 56
Codes and Standards 58
Other Performance Features 59

Introduction

The SG 5.0-145 is the second generation product series of the Siemens Gamesa 4.X Platform, which builds on the SG 4.5-145 design features and the Siemens Gamesa technological expertise and operational experience in the wind energy market.

With a 71m blade, a 5.0 MW generator and a tower portfolio with hub heights ranging from 79.5m to 165m, the SG 5.0-145 aims at becoming a new benchmark in the market for efficiency and profitability.

This Developer Package describes the turbine technical specifications and provides preliminary information for the main components and subsystems.

Information included in the present document is specific of the MY21 product configuration and must always be considered together.

For further information, please contact your regional SGRE Sales Manager.

Technical Description

Rotor-Nacelle
The rotor is a three-bladed construction, mounted upwind of the tower. The power output is controlled by pitch and torque demand regulation. The rotor speed is variable and is designed to maximize the power output while maintaining loads and noise level.

The nacelle has been designed for safe access to all service points during scheduled service. This allows a high quality service of the wind turbine and provides optimum troubleshooting conditions.

Blades
The SG 5.0-145 Siemens Gamesa blade is made up of fiberglass infusion-molded components. The blade structure uses aerodynamic shells containing embedded spar-caps, bonded to two main epoxy-fiberglass-balsa/foam-core shear webs. The SG 5.0-145 SGRE blade uses a blade design based on SGRE proprietary airfoils.

Rotor Hub
The rotor hub is cast in nodular cast iron and is fitted to the drive train low speed shaft with a flange connection. The hub is sufficiently large to provide room for service technicians during maintenance of blade roots and pitch bearings from inside the structure.

Drive train
The drive train is a 4-points suspension concept: main shaft with two main bearings and the gearbox with two torque arms assembled to the main frame.

The gearbox is in cantilever position; the gearbox planet carrier is assembled to the main shaft by means of a flange bolted joint and supports the gearbox.

Main Shaft
A forged main shaft ensures a comfortable access from the nacelle cover to the hub.

Main Bearings
The low speed shaft of the wind turbine is supported by two spherical roller bearings. The bearings are grease lubricated.

Gearbox
The gearbox is 3 stages high speed type (2 planetary + 1 parallel).

Generator
The generator is a doubly-fed asynchronous three phase generator with a wound rotor, connected to a frequency PWM converter. Generator stator and rotor are both made of stacked magnetic laminations and formed windings. Generator is cooled by air which is cooled with a liquid/air cooling system.

Mechanical Brake
The mechanical brake is fitted to the non-drive end of the gearbox.

Yaw System
A cast bed frame connects the drive train to the tower. The yaw bearing is an externally geared ring with a friction and sliding plain bearing. A series of electric planetary gear motors drives the yawing.

Nacelle Cover

The weather screen and housing around the machinery in the nacelle is made of fiberglass-reinforced laminated panels.

Tower

The wind turbine is as standard mounted on a tapered tubular steel tower. Other tower technologies are available for higher hub heights. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and internal electric lighting.

Controller

The wind turbine controller is a microprocessor-based industrial controller. The controller is complete with switchgear and protection devices. It is self-diagnosing and has a touch panel and display for easy readout of status and for adjustment of settings.

Converter

Connected directly with the Rotor, the Frequency Converter is a back to back 4Q conversion system with 2 VSC in a common DC-link. The Frequency Converter allows generator operation at variable speed and voltage, while supplying power at constant frequency and voltage to the MV transformer. The power conversion system is water cooled and has a modular arrangement for easy maintenance.

SCADA

The wind turbine provides connection to the SGRE SCADA system. This system offers remote control and a variety of status views and useful reports from a standard internet web browser. The status views present information including electrical and mechanical data, operation and fault status, meteorological data and grid station data.

Turbine Condition Monitoring

In addition to the SGRE SCADA system, the wind turbine is equipped with the unique SGRE condition monitoring setup. This system monitors the vibration level of the main components and compares the actual vibration spectra with a set of established reference spectra. Review of results, detailed analysis and reprogramming can all be carried out using a standard web browser.

Operation Systems

The wind turbine operates automatically. It is self-starting when the aerodynamic torque is enough. Below rated wind speed, the wind turbine controller fixes the pitch and torque references for operating in the optimum aerodynamic point (maximum production) taking into account the generator capability. Once rated wind speed is surpassed, the pitch position demand is adjusted to keep a stable power production equal to the nominal value. If high wind derated mode is enabled, the power production is limited once the wind speed exceeds a threshold value defined by design, until cut-out wind speed is reached and the wind turbine stops producing power. If the average wind speed exceeds the maximum operational limit, the wind turbine is shut down by pitching of the blades. When the average wind speed drops back below the restart average wind speed, the systems reset automatically.

Technical Specifications

Rotor
Type .... 3-bladed, horizontal axis
Position .... Upwind
Diameter .... 145 m
Swept area...................... 16,513 m²
Power regulation .... Pitch & torque regulation with variable speed
Rotor tilt........................... 6 degrees

Blade
Type .... Self-supporting
Blade length .... 71.0 m
Root chord .... 2.856 m
Aerodynamic profile .... Siemens Gamesa proprietary airfoils
Material .... GRE (Glassfiber Reinforced Epoxy)
Surface gloss .... Semi-gloss, < 30 / ISO2813
Surface color.................. Light grey, RAL 7035 or Papyrus White, RAL 9018

Aerodynamic Brake
Type .... Full span pitching
Activation .... Active, hydraulic

Load-Supporting Parts
Hub .... Nodular cast iron
Main shaft .... Forged steel
Nacelle bed frame.......... Nodular cast iron

Mechanical Brake
Type .... Hydraulic disc brake
Position .... Gearbox rear end

Nacelle Cover
Type .... Totally enclosed
Surface gloss .... Semi-gloss, <30 / ISO2813
Color .... Papyrus White, RAL 9018

Generator
Type .... Asynchronous, DFIG

Grid Terminals (LV)
Baseline nominal power.. 5.0 MW
Voltage .... 690 V
Frequency .... 50 Hz or 60 Hz

Yaw System
Type .... Active
Yaw bearing .... Externally geared
Yaw drive .... Electric gear motors
Yaw brake .... Active friction brake

Controller
Type .... SGRE Wind Turbine Control architecture
SCADA system .... SGRE SCADA System

Tower
Type .... Tubular steel / Hybrid

Hub height .... 79.5 - 165 m, site-specific

Corrosion protection .... Painted
Surface gloss .... Semi-gloss, <30 / ISO-2813

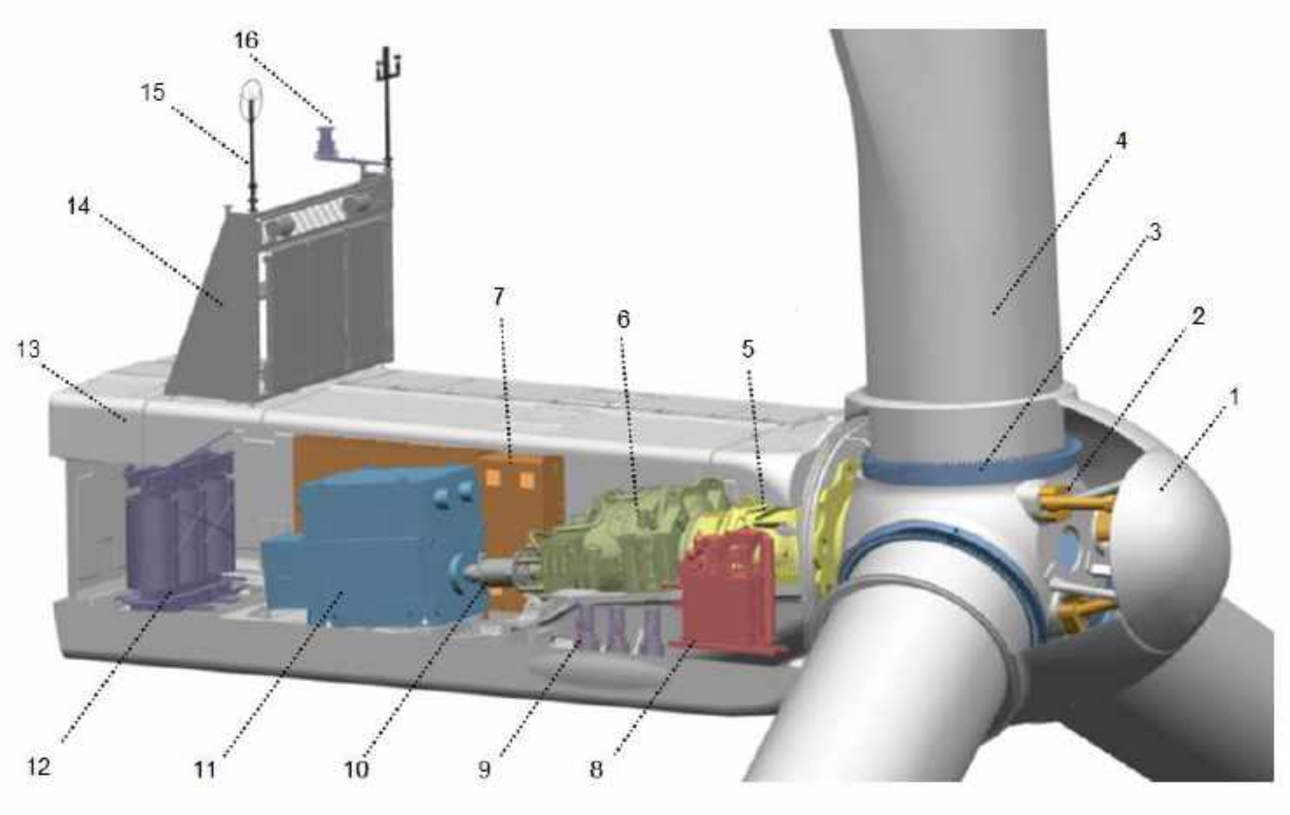
Color .... Papyrus White, RAL 9018

Operational Data
Cut-in wind speed .... 3 m/s
Rated wind speed .... 11.2 m/s (steady wind without turbulence, as defined by IEC61400-1)
Cut-out wind speed .... 27 m/s
Restart wind speed .... 24 m/s

Weight
Modular approach........... All modules weight lower than 95 t for transport

Nacelle Arrangement

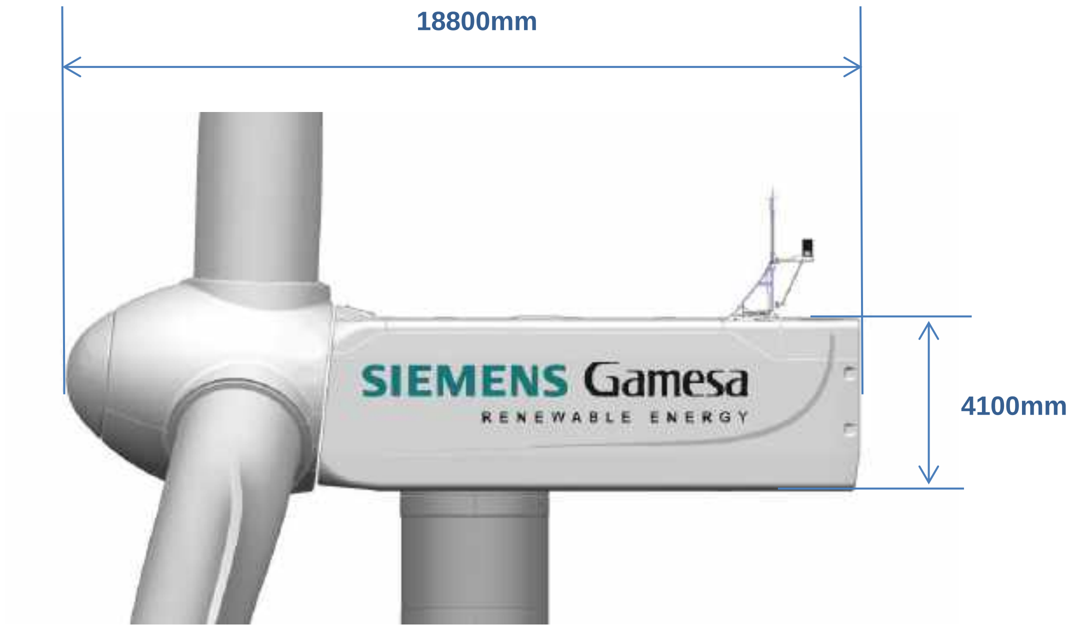
The design and layout of the nacelle are preliminary and may be subject to changes during the development of the product.

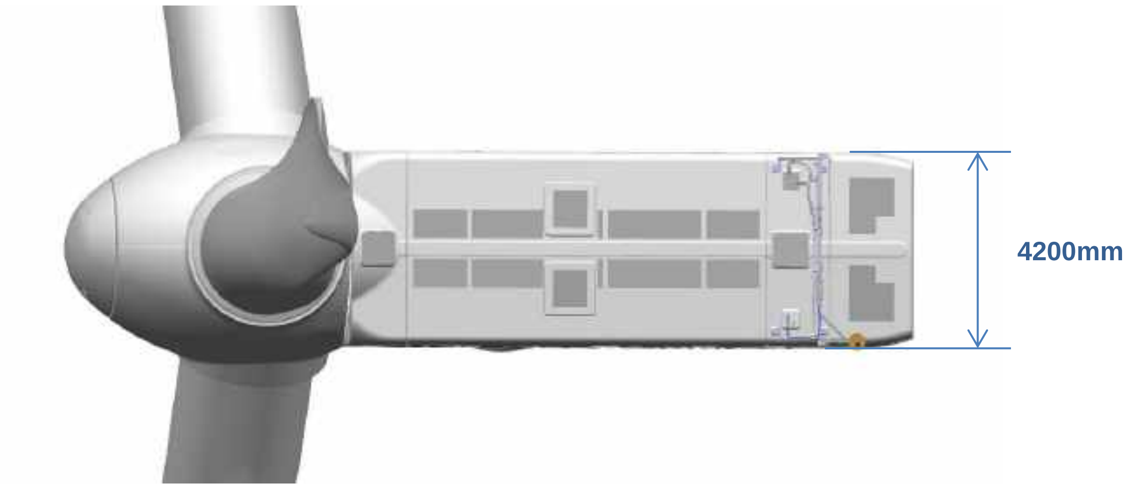


1	Rotor cover	**9**	Yaw system
2	Pitch system	**10**	High speed shaft
3	Blade bearings	**11**	Generator
4	Blades	**12**	Transformer
5	Low speed shaft	**13**	Nacelle cover
6	Gearbox	**14**	Cooling system
7	Electrical cabinets	**15**	Wind sensors
8	Hydraulic group	**16**	Beacon system

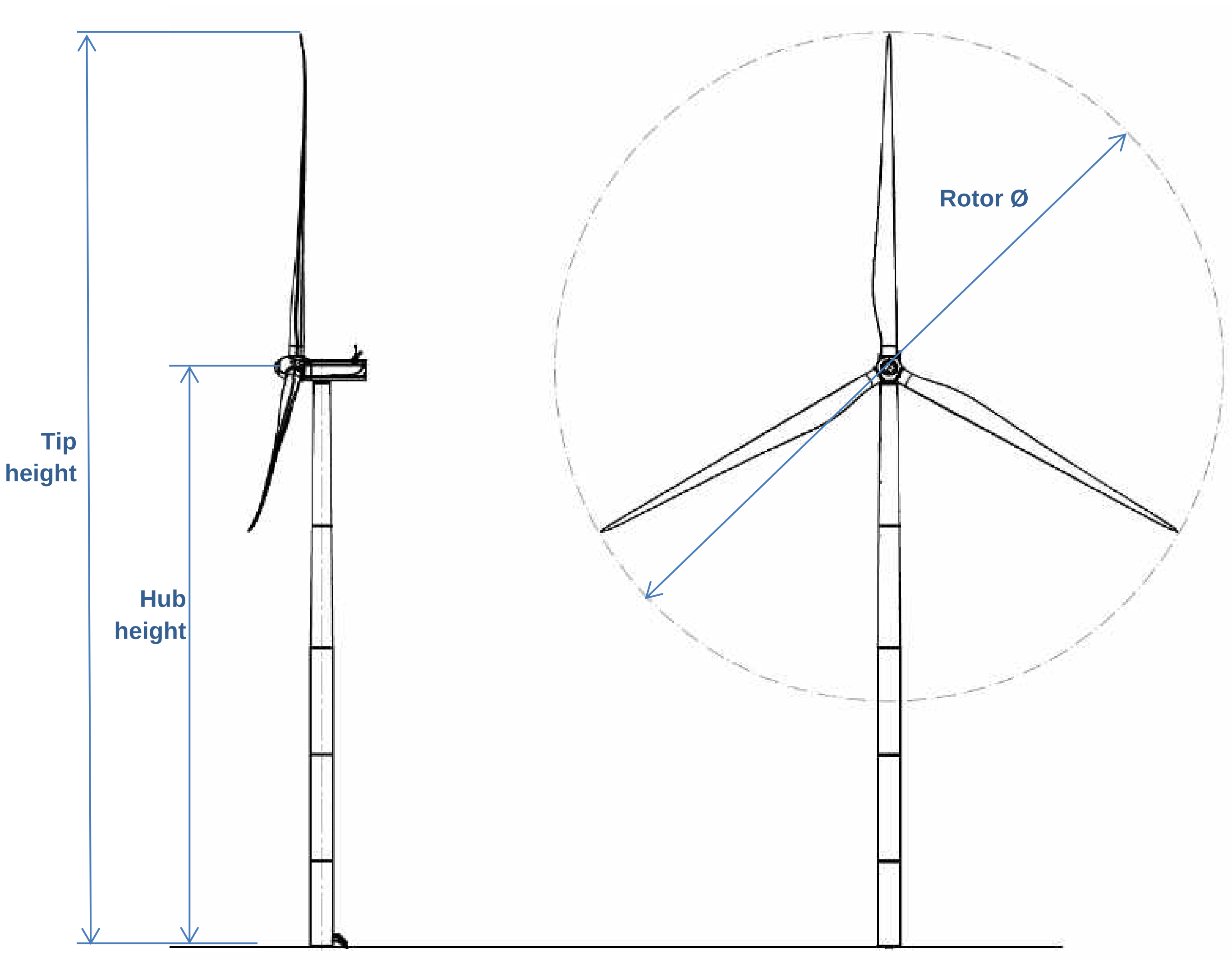
Nacelle Dimensions

The design and dimensions of the nacelle are preliminary and may be subject to changes during the development phases of the product.



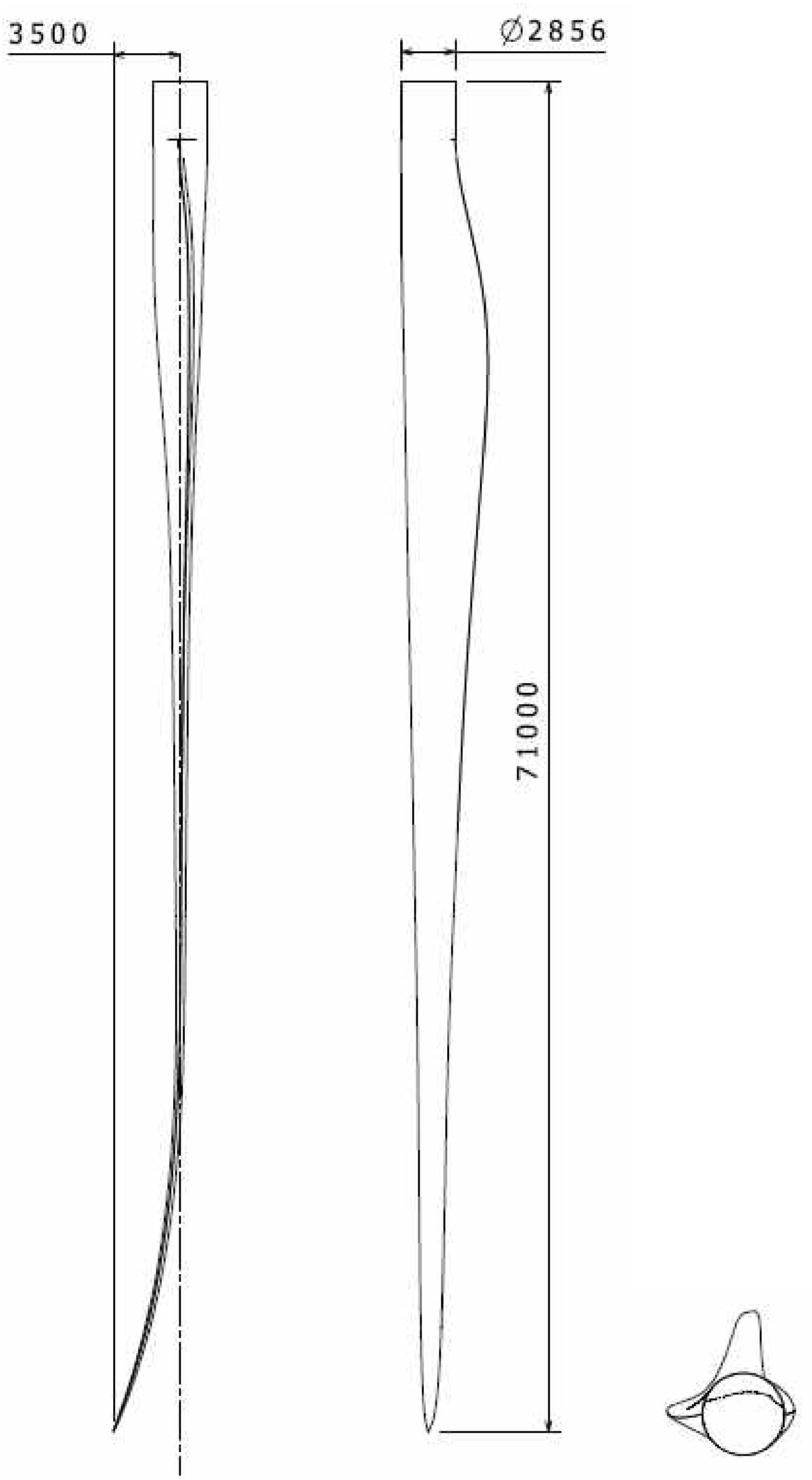


Elevation Drawing



Tip height	163.5m,	168m,	170m,	175m,	200m
Hub height	91m,	95.5m,	97.5m,	102.5m,	127.5m
Rotor diameter	145m				

Blade Drawing



Dimensions in millimeters.

Design Climatic Conditions

The design climatic conditions are the boundary conditions at which the turbine can be applied without supplementary design review. Applications of the wind turbine in more severe conditions may be possible, depending upon the overall circumstances. A project site-specific review requires the completion by the Client of the “Project Climatic Conditions” form.

Subject	ID	Issue	Unit	Value
Design Lifetime	0.1	Design lifetime definition	-	IEC 61400-1[1]
	0.2	Design lifetime	years	20
Wind, operation	1.1	Wind definitions	-	IEC 61400-1[1]
	1.2	IEC class	-	IIB
	1.3	Mean air density, ρ	kg/m^3	1.225
	1.4	Mean wind speed, V_{ave}	m/s	8.5
	1.5	Weibull scale parameter, A	m/s	9.59
	1.6	Weibull shape parameter, k	-	2
	1.7	Wind shear exponent, α	-	0.20
	1.8	Reference turbulence intensity at 15 m/s, I_{ref}	-	0.14
	1.9	Standard deviation of wind direction	Deg	8
	1.10	Maximum flow inclination	Deg	8
	1.11	Minimum turbine spacing, in rows	D	3
	1.12	Minimum turbine spacing, between rows	D	5
Wind, extreme	2.1	Wind definitions		IEC 61400-1
	2.2	Air density, ρ	kg/m^3	1.225
	2.3	Reference wind speed average over 10 min at hub height, V_{ref}	m/s	42.5
	2.4	Maximum 3 s gust in hub height, V_{e50}	m/s	59.5
	2.5	Maximum hub height power law index, α	-	0.11
Temperature	3.1	Temperature definitions	-	IEC 61400-1
	3.2	Minimum temperature, stand-still, $T_{min, s}$	Deg.C	-30
	3.3	Minimum temperature, operation, $T_{min, o}$	Deg.C	-20
	3.4	Maximum temperature, nominal operation, altitude below 1000m, $T_{max, o}$	Deg.C	+25 (Full Power) +45 (Power Derating) [2]
	3.5	Maximum temperature, stand-still, $T_{max, s}$	Deg.C	+50
Corrosion	4.1	Atmospheric-corrosivity category definitions	-	ISO 12944-2
	4.2	Internal nacelle environment (corrosivity category)	-	C3
	4.3	Exterior environment (corrosivity category)	-	C5-M
Lightning	5.1	Lightning definitions	-	IEC61400-24:2010
	5.2	Lightning protection level (LPL)	-	LPL 1
Dust	6.1	Dust definitions	-	IEC 60721-3-4:1995
	6.2	Working environmental conditions	mg/m^3	Average Dust Concentration (95% time) → 0.05 mg/m3

[1] All mentioning of IEC 61400-1 refers to IEC 61400-1 Ed3.0 2005/A1:2010.

[2] Operation maximum temperature is extended up to +45ºC including “Power Derating due to external ambient temperature and altitude” feature. See section “Other Performance Features” for further information.

Subject	ID	Issue	Unit	Value
Design Lifetime	0.1	Design lifetime definition	-	IEC 61400-1[1]
	0.2	Design lifetime	years	20
	6.3	Concentration of particles	mg/m^3	Peak Dust Concentration (95% time) → 0.5 mg/m3
Hail	7.1	Maximum hail diameter	mm	20
	7.2	Maximum hail falling speed	m/s	20
Ice	8.1	Ice definitions	-	-
	8.2	Ice conditions	Days/yr	7
Solar radiation	9.1	Solar radiation definitions	-	IEC 61400-1
	9.2	Solar radiation intensity	W/m^2	1000
Humidity	10.1	Humidity definition	-	IEC 61400-1
	10.2	Relative humidity	%	Up to 95
Obstacles	11.1	If the height of obstacles within 500m of any turbine location height exceeds 1/3 of (H – D/2) where H is the hub height and D is the rotor diameter then restrictions may apply. Please contact Siemens Gamesa Renewable Energy for information on the maximum allowable obstacle height with respect to the site and the turbine type.		

Standard Power Curve, Standard power operational mode

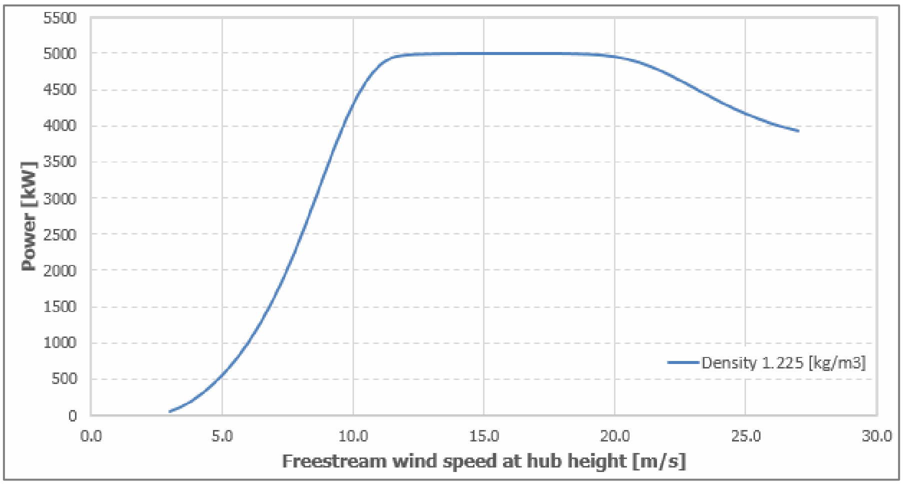
Air density 1.225 kg/m3
Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\% \frac{(0.75v_i + 5.6)}{v_i} < TI_i < 12\% \frac{(0.75v_i + 5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [°]	-2° ≤ β ≤ +2°
Grid frequency [Hz]	± 0.5 Hz

Other considerations: Clean rotor blades, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

Next table shows the electrical power [kW] as a function of the wind speed [m/s] horizontal referred to the hub height, averaged in ten minutes, for air density = 1.225 kg/m³. The power curve does not include losses in the transformer and high voltage cables. The power curve is for the standard version of the turbine.

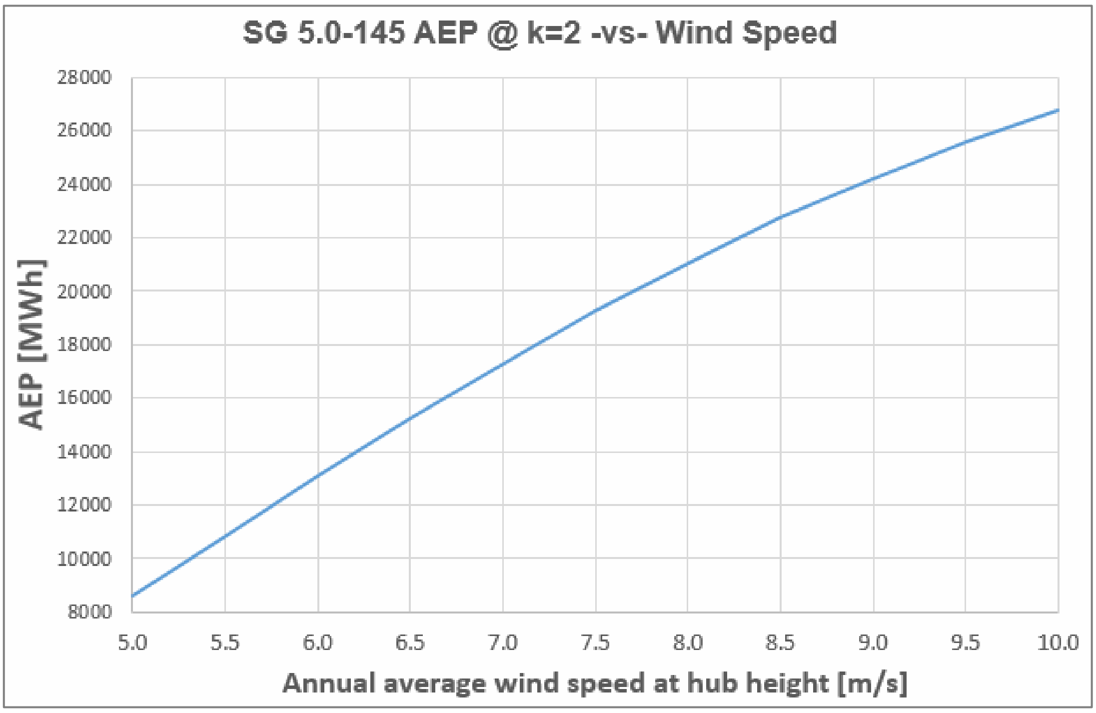
SG 5.0-145	
Wind Speed [m/s]	Power [kW]
3	56
4	241
5	555
6	1009
7	1638
8	2462
9	3421
10	4294
11	4829
12	4978
13	4995
14	4999
15	5000
16	5000
17	5000
18	4999
19	4990
20	4956
21	4869
22	4720
23	4531
24	4338
25	4169
26	4031
27	3930



The annual energy production data for different annual mean wind speeds in hub height are calculated from the above power curve assuming a Weibull wind speed distribution, 100 percent availability, and no reductions due to array losses, grid losses, or other external factors affecting the production.

AEP [MWh]		**Annual Average Wind Speed [m/s] at Hub Height**										
		5	***5.5***	***6***	***6.5***	***7***	***7.5***	***8***	***8.5***	***9***	***9.5***	***10***
Weibull K	***1.5***	9611	11492	13305	15018	16610	18068	19385	20560	21594	22490	23256
	2	8622	10836	13064	15241	17320	19272	21079	22734	24232	25573	26756
	2.5	7675	10014	12483	14979	17417	19737	21901	23890	25698	27328	28784

Annual Production [MWh] SG 5.0-145 wind turbine for the standard version, as a function of the annual mean wind speed at hub height, and for different Weibull parameters. Air density 1.225 kg/m3.



Standard Ct Curve, Standard power operational mode

Air density 1.225 kg/m3
Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\% \frac{(0.75v_i + 5.6)}{v_i} < TI_i < 12\% \frac{(0.75v_i + 5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [º]	-2º ≤ β ≤ +2º
Grid frequency [Hz]	± 0.5 Hz

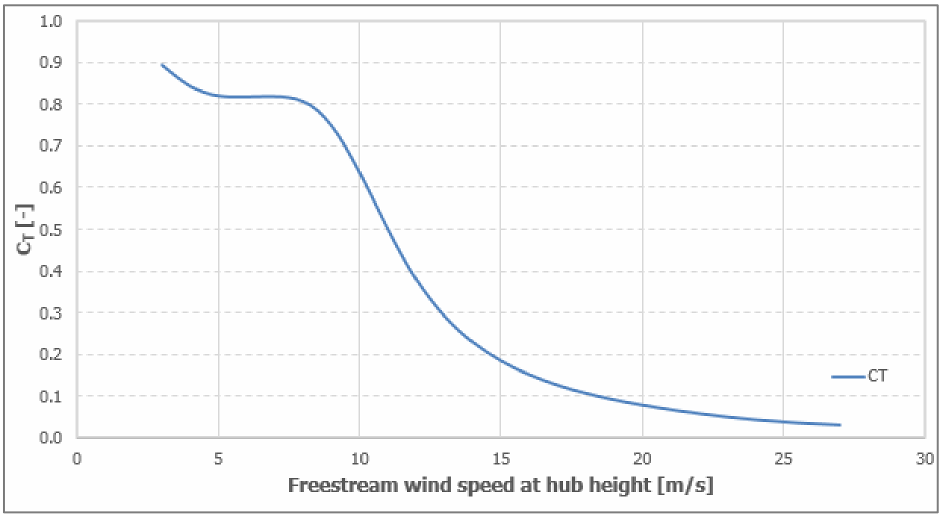
Other considerations: Clean rotor blades, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

The thrust coefficient Ct is used for the calculation of the wind speed deficit in the wake of a wind turbine.

Ct is defined by the following expression:
Ct = F / (0.5*ad*w^2*A)

where
F = Rotor force [N]
ad = Air density [kg/m3]
w = Wind speed [m/s]
A = Swept area of rotor [m2]

SG 5.0-145	
Wind Speed [m/s]	C_T [-]
3	0.8948
4	0.8438
5	0.8207
6	0.8185
7	0.8192
8	0.8075
9	0.7488
10	0.6360
11	0.4994
12	0.3794
13	0.2909
14	0.2283
15	0.1834
16	0.1502
17	0.1250
18	0.1054
19	0.0898
20	0.0769
21	0.0659
22	0.0564
23	0.0482
24	0.0415
25	0.0362
26	0.0319
27	0.0286



Power Curve, Air density, Standard power operational mode

Air density 1.225 kg/m3
Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\% \frac{(0.75v_i + 5.6)}{v_i} < TI_i < 12\% \frac{(0.75v_i + 5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [°]	-2° ≤ β ≤ +2°
Grid frequency [Hz]	± 0.5 Hz

Other considerations: Clean rotor blades, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

Next table shows the electrical power [kW] as a function of the wind speed [m/s] horizontal referred to the hub height, averaged in ten minutes, for different air densities [kg/m^3]. The power curve does not include losses in the transformer and high voltage cables. The power curve is for the standard version of the turbine.

P [kW]	***Air Density [kg/m3]***								
Wind Speed [m/s]	**1.225**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
3	56	41	44	46	49	52	54	57	60
4	241	200	207	215	222	230	237	245	252
5	555	471	486	502	517	532	547	563	578
6	1009	864	891	917	943	969	996	1022	1048
7	1638	1409	1451	1492	1534	1576	1617	1659	1700
8	2462	2123	2185	2246	2308	2370	2431	2493	2554
9	3421	2961	3046	3130	3214	3297	3380	3461	3541
10	4294	3799	3898	3994	4085	4173	4255	4332	4403
11	4829	4484	4565	4638	4702	4759	4808	4848	4881
12	4978	4882	4918	4942	4958	4969	4975	4980	4984
13	4995	4982	4986	4989	4991	4993	4994	4995	4996
14	4999	4995	4996	4997	4998	4998	4999	4999	4999
15	5000	4999	4999	4999	4999	5000	5000	5000	5000
16	5000	5000	5000	5000	5000	5000	5000	5000	5000
17	5000	5000	5000	5000	5000	5000	5000	5000	5000
18	4999	4999	4999	4999	4999	4999	4999	4999	4999
19	4990	4990	4990	4990	4990	4990	4990	4990	4990
20	4956	4956	4956	4956	4956	4956	4956	4956	4956
21	4869	4869	4869	4869	4869	4869	4869	4869	4869
22	4720	4720	4720	4720	4720	4720	4720	4720	4720
23	4531	4531	4531	4531	4531	4531	4531	4531	4531
24	4338	4338	4338	4338	4337	4338	4338	4338	4338
25	4169	4168	4169	4168	4168	4168	4168	4168	4168
26	4031	4031	4031	4031	4031	4031	4031	4031	4031
27	3930	3930	3930	3930	3930	3930	3930	3930	3930

The annual energy production data for different annual mean wind speeds in hub height are calculated from the above power curve assuming a Rayleigh wind speed distribution, 100 percent availability, and no reductions due to array losses, grid losses, or other external factors affecting the production.

AEP [MWh] @ k=2		**Annual Average Wind Speed [m/s] at Hub Height**										
		5.0	***5.5***	***6.0***	***6.5***	***7.0***	***7.5***	***8.0***	***8.5***	***9.0***	***9.5***	***10.0***
Density [kg/m³]	***1.06***	7557	9597	11692	13775	15797	17723	19529	21202	22732	24114	25345
	1.09	7757	9833	11955	14059	16095	18027	19836	21507	23032	24407	25629
	1.12	7955	10063	12213	14335	16383	18322	20131	21799	23319	24686	25900
	1.15	8149	10290	12464	14604	16662	18605	20415	22080	23594	24954	26159
	1.18	8341	10512	12709	14865	16932	18879	20689	22350	23858	25210	26406
	1.21	8529	10729	12947	15118	17193	19143	20952	22609	24110	25454	26642
	1.225	8622	10836	13064	15241	17320	19272	21079	22734	24232	25573	26756
	1.24	8715	10941	13180	15363	17446	19398	21205	22857	24352	25688	26867
	1.27	8897	11150	13407	15602	17690	19644	21448	23096	24584	25912	27083

Annual Production [MWh] SG 5.0-145 wind turbine for the standard version, as a function of the annual mean wind speed at hub height and for different air densities considering a Rayleigh wind speed distribution.

Ct Curve, Air Density, Standard power operational mode

Air density 1.225 kg/m3
Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\%\frac{(0.75v_i+5.6)}{v_i} < TI_i < 12\%\frac{(0.75v_i+5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [º]	-2º ≤ β ≤ +2º
Grid frequency [Hz]	± 0.5 Hz

Other considerations: Clean rotor blades, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

The calculated Ct curve data are valid for air densities as stated below, clean rotor blades, substantially horizontal, undisturbed air flow, normal turbulence intensity and normal wind shear.

CT [-]	***Air Density [kg/m3]***								
Wind Speed [m/s]	**1.225**	**1.06**	**1.09**	**1.12**	**1.15**	**1.18**	**1.21**	**1.24**	**1.27**
3	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948
4	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438
5	0.8207	0.8194	0.8197	0.8199	0.8202	0.8204	0.8206	0.8207	0.8209
6	0.8185	0.8176	0.8178	0.8180	0.8181	0.8183	0.8184	0.8185	0.8186
7	0.8192	0.8189	0.8189	0.8190	0.8191	0.8191	0.8192	0.8192	0.8193
8	0.8075	0.8074	0.8074	0.8075	0.8075	0.8075	0.8075	0.8075	0.8075
9	0.7488	0.7513	0.7512	0.7510	0.7506	0.7501	0.7493	0.7482	0.7468
10	0.6360	0.6559	0.6538	0.6512	0.6478	0.6437	0.6387	0.6330	0.6266
11	0.4994	0.5442	0.5376	0.5301	0.5220	0.5134	0.5041	0.4946	0.4849
12	0.3794	0.4324	0.4228	0.4131	0.4034	0.3937	0.3841	0.3748	0.3657
13	0.2909	0.3375	0.3283	0.3194	0.3108	0.3026	0.2947	0.2871	0.2800
14	0.2283	0.2655	0.2579	0.2507	0.2439	0.2374	0.2313	0.2255	0.2199
15	0.1834	0.2127	0.2067	0.2010	0.1956	0.1906	0.1857	0.1812	0.1769
16	0.1502	0.1736	0.1688	0.1643	0.1600	0.1559	0.1521	0.1484	0.1450
17	0.1250	0.1441	0.1401	0.1364	0.1329	0.1296	0.1265	0.1235	0.1207
18	0.1054	0.1212	0.1179	0.1148	0.1120	0.1092	0.1066	0.1042	0.1018
19	0.0898	0.1030	0.1003	0.0977	0.0953	0.0930	0.0908	0.0887	0.0868
20	0.0769	0.0881	0.0858	0.0836	0.0816	0.0796	0.0778	0.0761	0.0744
21	0.0659	0.0753	0.0734	0.0716	0.0699	0.0682	0.0667	0.0652	0.0638
22	0.0564	0.0643	0.0626	0.0611	0.0597	0.0583	0.0570	0.0558	0.0546
23	0.0482	0.0548	0.0535	0.0522	0.0510	0.0498	0.0487	0.0477	0.0467
24	0.0415	0.0471	0.0460	0.0449	0.0439	0.0429	0.0420	0.0411	0.0402
25	0.0362	0.0410	0.0400	0.0391	0.0382	0.0374	0.0366	0.0358	0.0351
26	0.0319	0.0362	0.0353	0.0345	0.0337	0.0330	0.0323	0.0316	0.0310
27	0.0286	0.0324	0.0316	0.0309	0.0302	0.0295	0.0289	0.0283	0.0278

Standard Acoustic Emission

Noise Level (LW): Values reported correspond to the average estimated Sound Power Level emitted by the WTG at hub height, called LW in TS IEC-61400-14. LW values are expressed in dB(A). To obtain LWd value, as defined in IEC-61400-14, it must be applied a 2 dB increase to LW.

dB(A): LW is expressed in decibels applying the “A” filter as required by IEC.

Noise generated at standard power operation mode LW is **106.3 dB(A).**

SG 5.0-145	
Wind Speed [m/s]	**LW [dB(A)]**
3.0	95.1
3.5	95.1
4.0	95.1
4.5	95.1
5.0	95.1
5.5	97.2
6.0	99.2
6.5	101.1
7.0	102.7
7.5	104.3
8.0	105.7
8.5	106.3
9.0	106.3
9.5	106.3
10.0	106.3
10.5	106.3
11.0	106.3
11.5	106.3
12.0	106.3
12.5	106.3
13.0	106.3
13.5	106.3
14.0	106.3
14.5	106.3
Up to cut out	≤106.3

Noise values included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Noise Reduction System (NRS) operational modes

The Noise Reduction System NRS is an optional module available with the basic SCADA configuration and it therefore requires the presence of a SGRE SCADA system to work.

The purpose of this system is to limit the noise emitted by any of the functioning turbines and thereby comply with local regulations regarding noise emissions. This allows wind farms to be located close to urban areas, limiting the environmental impact that they imply.

Noise control is achieved through reducing the active power and rotational speed of the wind turbine. This reduction is dependent on the wind speed.

The task of the Noise Reduction System is to control the noise settings of each turbine to the most appropriate level at all times, in order to keep the noise emissions within the limits allowed.

In order to do this, the SCADA control has to consider the wind speed of each turbine, its direction, and a configured schedule/calendar.

There can be up to 8 low noise modes, besides the full operation one. Noise levels corresponding to each mode are the following:

Mode:	FP	N1	N2	N3	N4	N5	N6	N7	N8
Noise Level [dB(A)]	106.3	105.7	105.2	103.7	102.7	101.7	99.9	99	98

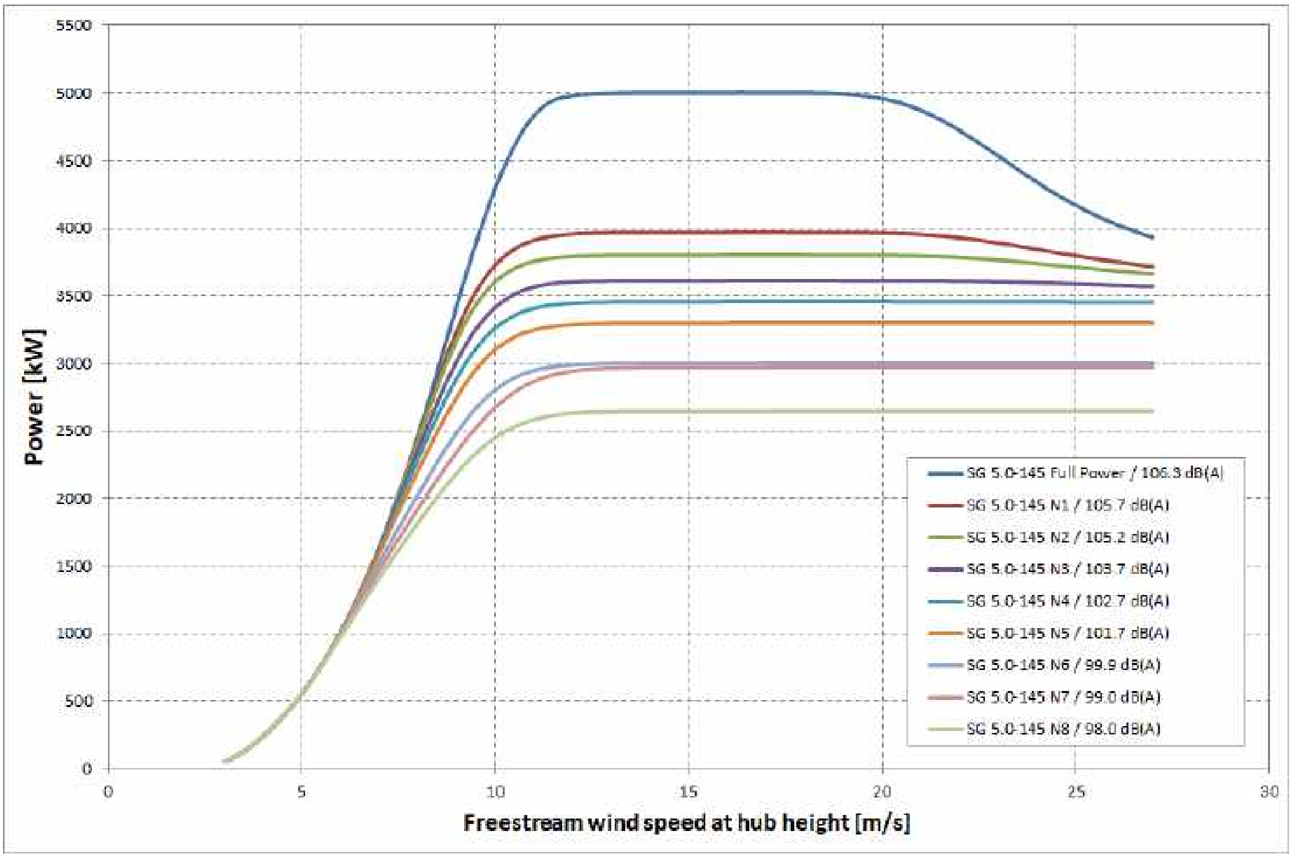
Noise values included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Depending on the type of tower selected, some of the low noise modes defined above may not be compatible. In the following table, feasibility of low noise modes vs tower is presented. Low noise modes feasibility vs other tower designs will be analyzed upon request.

SG 5.0-145	N1	N2	N3	N4	N5	N6	N7	N8
H= 91.0 m (Steel, baseline design)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H= 95.5 m (Steel, baseline design)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H= 97.5 m (Steel, baseline design)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H= 102.5 m (Steel, baseline design)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
H= 127.5 m (Steel, baseline design)	No	No	No	No	Yes	Yes	Yes	Yes

Next table presents the power production as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings.

P [kW]	***Low Noise Operation Mode***							
Wind Speed [m/s]	**N1 105.7 dB(A)**	**N2 105.2 dB(A)**	**N3 103.7 dB(A)**	**N4 102.7 dB(A)**	**N5 101.7 dB(A)**	**N6 99.9 dB(A)**	**N7 99.0 dB(A)**	**N8 98.0 dB(A)**
3	56	56	56	56	56	56	56	56
4	241	241	241	241	241	241	241	241
5	555	555	555	555	555	555	555	554
6	1009	1009	1009	1008	1007	1000	990	974
7	1637	1636	1629	1615	1592	1521	1470	1410
8	2437	2422	2355	2286	2203	2027	1925	1819
9	3232	3170	3016	2884	2747	2484	2344	2183
10	3725	3604	3416	3257	3101	2803	2677	2449
11	3907	3755	3567	3402	3246	2946	2869	2583
12	3952	3791	3605	3440	3286	2988	2945	2630
13	3962	3798	3613	3448	3294	2998	2967	2642
14	3963	3800	3615	3450	3296	3000	2973	2644
15	3964	3800	3615	3450	3296	3000	2974	2645
16	3964	3800	3615	3450	3296	3000	2974	2645
17	3964	3800	3615	3450	3296	3000	2974	2645
18	3964	3800	3615	3450	3296	3000	2974	2645
19	3963	3800	3615	3450	3296	3000	2974	2645
20	3960	3799	3615	3450	3296	3000	2974	2645
21	3949	3795	3614	3450	3296	3000	2974	2645
22	3925	3784	3612	3450	3296	3000	2974	2645
23	3887	3765	3607	3449	3296	3000	2974	2645
24	3841	3740	3599	3449	3296	3000	2974	2645
25	3794	3713	3590	3448	3296	3000	2974	2645
26	3750	3685	3580	3446	3296	3000	2974	2645
27	3715	3663	3571	3445	3296	3000	2974	2645


Power [kW]
Freestream wind speed at hub height [m/s]
SG 5.0-145 Full Power / 106.3 dB(A)
SG 5.0-145 N1 / 105.7 dB(A)
SG 5.0-145 N2 / 105.2 dB(A)
SG 5.0-145 N3 / 103.7 dB(A)
SG 5.0-145 N4 / 102.7 dB(A)
SG 5.0-145 N5 / 101.7 dB(A)
SG 5.0-145 N6 / 99.9 dB(A)
SG 5.0-145 N7 / 99.0 dB(A)
SG 5.0-145 N8 / 98.0 dB(A)

Next table presents the Ct as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings. The calculated Ct curve data are valid for clean rotor blades, substantially horizontal, undisturbed air flow, normal turbulence intensity and normal wind shear.

C_T [-]	***Low Noise Operation Mode***							
Wind Speed [m/s]	**N1 105.7 dB(A)**	**N2 105.2 dB(A)**	**N3 103.7 dB(A)**	**N4 102.7 dB(A)**	**N5 101.7 dB(A)**	**N6 99.9 dB(A)**	**N7 99.0 dB(A)**	**N8 98.0 dB(A)**
3	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948	0.8948
4	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438	0.8438
5	0.8207	0.8207	0.8207	0.8207	0.8207	0.8204	0.8197	0.8176
6	0.8185	0.8184	0.8182	0.8171	0.8138	0.7952	0.7753	0.7472
7	0.8174	0.8158	0.8027	0.7844	0.7575	0.6907	0.6501	0.6081
8	0.7860	0.7747	0.7256	0.6846	0.6412	0.5631	0.5240	0.4862
9	0.6836	0.6616	0.6032	0.5618	0.5229	0.4570	0.4249	0.3909
10	0.5319	0.5084	0.4675	0.4376	0.4103	0.3623	0.3420	0.3102
11	0.3933	0.3747	0.3496	0.3297	0.3117	0.2785	0.2694	0.2412
12	0.2938	0.2802	0.2636	0.2498	0.2372	0.2136	0.2098	0.1867
13	0.2261	0.2160	0.2039	0.1937	0.1843	0.1666	0.1646	0.1464
14	0.1788	0.1710	0.1617	0.1538	0.1465	0.1328	0.1314	0.1170
15	0.1445	0.1384	0.1310	0.1247	0.1189	0.1079	0.1068	0.0953
16	0.1190	0.1140	0.1079	0.1028	0.0981	0.0891	0.0882	0.0788
17	0.0994	0.0953	0.0903	0.0860	0.0821	0.0747	0.0739	0.0661
18	0.0841	0.0807	0.0764	0.0728	0.0696	0.0633	0.0626	0.0561
19	0.0719	0.0690	0.0654	0.0624	0.0596	0.0543	0.0537	0.0481
20	0.0621	0.0597	0.0565	0.0539	0.0515	0.0470	0.0464	0.0417
21	0.0540	0.0520	0.0493	0.0471	0.0450	0.0410	0.0405	0.0364
22	0.0473	0.0456	0.0434	0.0414	0.0396	0.0361	0.0357	0.0321
23	0.0416	0.0404	0.0385	0.0368	0.0352	0.0321	0.0317	0.0286
24	0.0369	0.0360	0.0345	0.0330	0.0316	0.0289	0.0285	0.0257
25	0.0330	0.0323	0.0312	0.0299	0.0286	0.0261	0.0258	0.0233
26	0.0298	0.0293	0.0284	0.0273	0.0261	0.0239	0.0235	0.0212
27	0.0271	0.0267	0.0260	0.0251	0.0240	0.0219	0.0216	0.0195

The table below contains the noise levels as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings.

Noise [dB(A)]	***Low Noise Operation Mode***							
Wind Speed [m/s]	**N1 105.7 dB(A)**	**N2 105.2 dB(A)**	**N3 103.7 dB(A)**	**N4 102.7 dB(A)**	**N5 101.7 dB(A)**	**N6 99.9 dB(A)**	**N7 99.0 dB(A)**	**N8 98.0 dB(A)**
3.0	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
3.5	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
4.0	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
4.5	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
5.0	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
5.5	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2
6.0	99.2	99.2	99.2	99.2	99.2	99.2	99.0	98.0
6.5	101.1	101.1	101.1	101.1	101.1	99.9	99.0	98.0
7.0	102.7	102.7	102.7	102.7	101.7	99.9	99.0	98.0
7.5	104.3	104.3	103.7	102.7	101.7	99.9	99.0	98.0
8.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
8.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
9.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
9.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
10.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
10.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
11.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
11.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
12.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
12.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
13.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
13.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
14.0	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
14.5	105.7	105.2	103.7	102.7	101.7	99.9	99.0	98.0
Up to cut out	≤105.7	≤105.2	≤103.7	≤102.7	≤101.7	≤99.9	≤99.0	≤98.0

Noise values included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

The 1/3 octave band noise spectra expressed as A-weighted sound power level for a given frequency band is shown below for 12m/s at hub height, for the standard power operation setting as well as the low noise modes.

	Noise [dB(A)]								
1/3 octave band, center frequency [Hz]	**Standard Power 5.0MW**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**
	106.3 dB(A)	**105.7 dB(A)**	**105.2 dB(A)**	**103.7 dB(A)**	**102.7 dB(A)**	**101.7 dB(A)**	**99.9 dB(A)**	**99.0 dB(A)**	**98.0 dB(A)**
10	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1	46.1
12.5	51.8	51.8	51.8	51.8	51.8	51.8	51.8	51.7	51.7
16	57.5	57.4	57.4	57.4	57.4	57.4	57.3	57.3	57.3
20	62.8	62.8	62.8	62.7	62.6	62.6	62.5	62.4	62.3
25	67.4	67.3	67.3	67.1	67.0	66.9	66.7	66.6	66.5
31.5	72.0	71.9	71.8	71.6	71.4	71.3	71.0	70.8	70.7
40	76.1	75.9	75.8	75.5	75.3	75.1	74.6	74.4	74.2
50	80.6	80.4	80.2	79.8	79.5	79.2	78.6	78.3	78.0
63	84.7	84.5	84.3	83.7	83.3	82.9	82.2	81.8	81.4
80	87.1	86.8	86.5	85.8	85.3	84.8	83.8	83.4	82.8
100	88.8	88.4	88.1	87.2	86.6	86.0	84.8	84.2	83.6
125	90.1	89.7	89.3	88.2	87.5	86.7	85.3	84.6	83.8
160	90.9	90.4	90.0	88.6	87.7	86.8	85.2	84.3	83.4
200	91.9	91.2	90.7	89.2	88.1	87.1	85.2	84.2	83.2
250	93.4	92.7	92.2	90.7	89.6	88.6	86.7	85.7	84.7
315	93.7	93.1	92.6	91.0	90.0	89.0	87.1	86.1	85.0
400	93.5	92.8	92.3	90.8	89.7	88.7	86.8	85.8	84.7
500	93.6	92.9	92.4	90.9	89.8	88.8	86.9	85.9	84.8
630	95.2	94.5	94.0	92.5	91.4	90.4	88.5	87.5	86.4
800	95.0	94.3	93.8	92.3	91.2	90.2	88.3	87.3	86.3
1000	96.0	95.3	94.8	93.3	92.2	91.2	89.3	88.3	87.3
1250	96.7	96.0	95.5	94.0	92.9	91.9	90.0	89.0	88.0
1600	96.6	95.9	95.4	93.9	92.8	91.8	89.9	88.9	87.9
2000	95.5	94.8	94.3	92.8	91.7	90.7	88.8	87.8	86.8
2500	94.1	93.4	92.9	91.4	90.3	89.3	87.4	86.4	85.4
3150	91.9	91.2	90.7	89.2	88.1	87.1	85.2	84.2	83.2
4000	88.8	88.1	87.6	86.1	85.0	84.0	82.1	81.1	80.1
5000	84.5	83.8	83.3	81.8	80.7	79.7	77.8	76.8	75.8
6300	79.3	78.6	78.1	76.6	75.5	74.5	72.6	71.6	70.6
8000	73.5	72.8	72.3	70.8	69.7	68.7	66.8	65.8	64.8
10000	68.9	68.2	67.7	66.2	65.1	64.1	62.2	61.2	60.2

Further information about noise spectra, including other wind speeds, is available upon request.
Noise values included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Electrical Specifications

Nominal output and grid conditions

Nominal power	5000 kW
Nominal voltage	690 V
Power factor correction.....	Frequency converter control
Power factor range	0.9 capacitive to 0.9 inductive at nominal balanced voltage

Generator

Type.................................	DFIG Asynchronous
Maximum power	5150 kW
Nominal speed.................	1120 rpm-6p (50Hz) 1344 rpm-6p (60Hz)

Generator Protection

Insulation class	Stator F/H Rotor F/H
Winding temperatures......	6 Pt 100 sensors
Bearing temperatures	2 Pt 100
Slip Rings	1 Pt 100
Grounding brush…... ..…	On side no coupling

Generator Cooling

Cooling system	Liquid cooling
Internal ventilation	Air
Control parameter............	Winding, Liquid, Bearings temperature

Frequency Converter

Operation..........................	4Q B2B Partial Load
Switching	PWM
Switching freq., grid side...	2.5 kHz
Cooling	Liquid/Air

Main Circuit Protection

Short circuit protection	Circuit breaker
Surge arrester..................	varistors

Peak Power Levels

10 min average................	Limited to nominal

Grid Requirements

Nominal grid frequency	50 or 60 Hz
Minimum voltage................	90 % of nominal
Maximum voltage...............	112 % of nominal
Minimum frequency............	94 % of nominal
Maximum frequency...........	106 % of nominal
Maximum voltage imbalance (negative sequence of component voltage).	≤5 %
Max short circuit level at controller's grid Terminals (690 V)	67 kA

Power Consumption from Grid (approximately)

At stand-by,No yawing	10 kW
At stand-by, yawing............	41 kW

Controller back-up

UPS Controller system.......	Online UPS, Li battery
Back-up time	1 min
Back-up time Scada………	24 h

Transformer Requirements

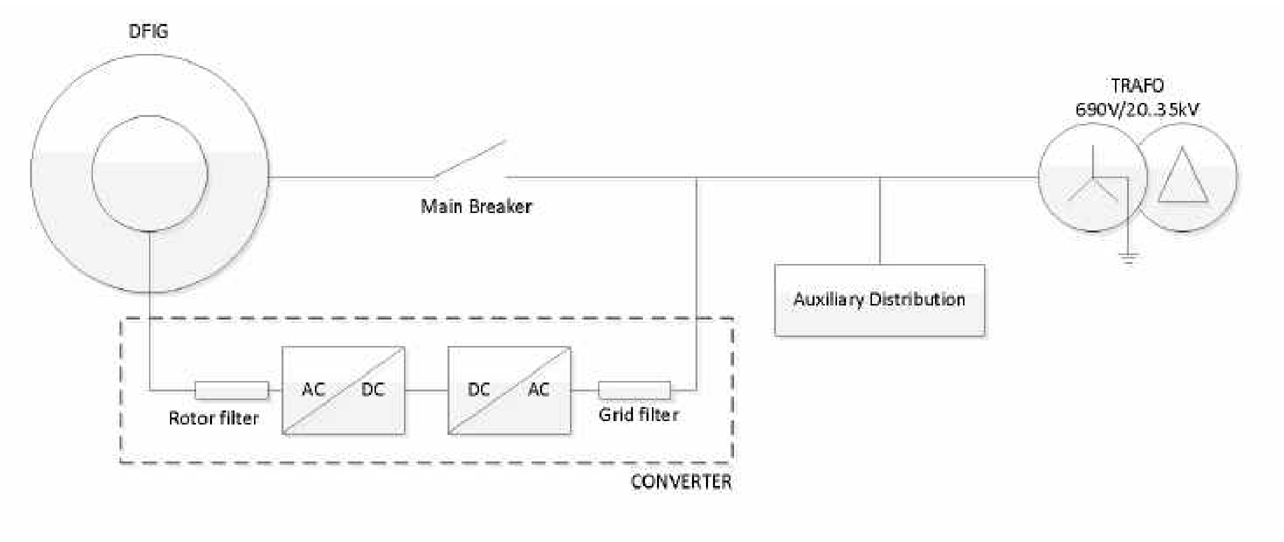
Transformer impedance requirement........................	8.0 % -9.5%
Secondary voltage	690 V
Vector group	Dyn 11 or Dyn 1 (star point earthed)

Earthing Requirements

Earthing system	Acc. to IEC62305-3 ED 1.0:2006
Foundation reinforcement ..	Must be connected to earth electrodes
Foundation terminals	Acc. to SGRE Standard
HV connection...................	HV cable shield shall be connected to earthing system

All data are subject to tolerances in accordance with IEC.

Simplified Single Line Diagram



Transformer Specifications ECO 20 kV*

Transformer

Type	Dry type
Nominal power	5500 kVA @nominal voltage +12%/-10 %
Nominal voltage	20/0.69 kV
Frequency	50 Hz
Transformer impedance	8.59%
Loss (P_0 /$P_{n120^\circ C}$)...............	8/45 kW
Vector group	Dyn11
Offload tap changer	Optional (±2.5% / ±5%)
Standard…………………....	IEC 60076 ECO Design Directive

Transformer Cooling

Cooling system……………	AF
Ventilation …………………	Forced ventilation of the transformer room
Control parameter.............	Winding & Magnetic core temperature

Transformer Monitoring

WindingTemperature………	PT100 sensor
Mag. Core temperature…	PT100 sensor

Transformer Earthing

Star point	The star point of the transformer must be connected to earth

Transformer Specifications 34.5 kV*

Transformer

Type	Dry type
Nominal power	5500 kVA @nominal voltage +12/-10 %
Nominal voltage	34.5/0.69 kV
Frequency	60 Hz
Transformer impedance	8.77%
Loss (P_0 /$P_{n120^\circ C}$)...............	8/45 kW
Vector group	Dyn1
Offload tap changer	Optional (±2.5% / ±5%)
Standard…………………....	IEEE std C57.12

Transformer Cooling

Cooling system……………	AF
Ventilation …………………	Forced ventilation of the transformer room
Control parameter.............	Winding & Magnetic core temperature

Transformer Monitoring

WindingTemperature………	PT100 sensor
Mag. Core temperature…	PT100 sensor

Transformer Earthing

Star point	The star point of the transformer must be connected to earth

Switchgear Specification

The installation of a switchgear is an option available upon request. The minimum requirements that must be complied with, from the point of view of electrical protection, are:

Switchgear Specification (38 kV)

Technical Data for Switchgear

Switchgear	
Type	Gas-insulated switchgear
Operating voltage	30 - 36 kV
Rated current	630 A
Short time withstand current	20 kA/1s
Peak withstand current	50 kA
Power frequency withstand voltage	70 kV
Lightning withstand voltage	170 kV
Insulating medium	SF_6
Switching medium	vacuum
Consist of	1, 2 or 3 panels
Grid cable feeder	Load break switch or direct cable riser
Circuit breaker feeder	Circuit breaker
Degree of protection, vessel	IPX8
Degree of protection, front cover	IP2XD
Degree of protection, LV Comp.	IP2XD
Internal arc classification IAC:	A FL 20 kA 1s
Pressure relief	Down
Standard	IEC 62271
Temperature range	-30°C to +40°C
Grid Cable feeder	
Rated current , cubicle	630 A
Rated current , load breaker	630 A
Short time withstand current	20 kA/1s
Short circuit making current	50 kA/1s
Three position switch	Closed, open, earthed
Switch mechanism	Spring operated
Control	Local
Voltage detection system	Capacitive

Circuit breaker feeder	
Rated current , Cubicle	630 A
Rated current , circuit breaker	630 A
Short time withstand current	20 kA/1s
Short circuit making current	50 kA/1s
Short circuit breaking current	20 kA/1s
Three position CB switch	Closed, open, earthed
Switch mechanism	Spring operated
Tripping mechanism	Stored energy
Motor voltage	Under request
Control	Local
Coil for external trip	230 V AC
Voltage detection system	Capacitive
Protection	
Over-current relay	Ekor.wtp
Functions	50/51 50N/51N
Power supply	Dual (Self & Aux. powered)
Current transformer	300/1A; 0.18VA, Cl. 5P20
Interface- MV Cables	
Grid cable feeder	630A bushings type C M16 Max 2 feeder cables
Cable entry	From bottom
Cable clamp size (cable outer diameter)	up to 48mm
Circuit breaker feeder	630 A bushings type C M16
Cable entry	From bottom
Interface to turbine control	
Breaker status	1 NO + 1 NC contacts
Insulation supervision	Under request
External trip	230 V AC

All data are subject to tolerances in accordance with IEC.
Example for a 38 kV Switchgear. For other Medium Voltage variants or different grounding systems, contact SGRE.

Preliminary Foundation Loads

Detailed information about foundation loads will be available upon request.

Tower Dimensions

SG 5.0-145 presents a tower portfolio with hub heights ranging from 79.5m to 165m. Information for the baseline towers is included below:

- Tower hub height 91m. Baseline design (T91.41).

TOWER HH 91 SG 5.0-145			
	Section 1 (bottom)	Section 2	Section 3 (top)
External diameter upper flange (m)	4.224	3.481	3.503
External diameter lower flange (m)	4.470	4.224	3.481
Section's height (m)	25.073	29.260	34.500
Section structural weight (kgs)	76134.7	61649.8	55581.0
Section total weight (kgs)	78556.7	62966.5	57133.5
Total tower height (m)	**88.833**		
Total tower weight (kg)	**198656.7**		

- Tower hub height 95.5m. Baseline design (4 sections, T95.5.41).

TOWER HH 95.5 SG 5.0-145				
	Section 1 (bottom)	Section 2	Section 3	Section 4 (top)
External diameter upper flange (m)	4.4987	4.4933	3.9677	3.5030
External diameter lower flange (m)	4.5000	4.4987	4.4933	3.9677
Section's height (m)	17.940	24.535	25.897	25.120
Section structural weight (kgs)	61029.0	59730.0	47174.0	40929.8
Section total weight (kgs)	63177.7	60834.1	48339.4	42060.2
Total tower height (m)	**93.492**			
Total tower weight (kg)	**214411.4**			

- Tower hub height 97.5m. Baseline design (4 sections, T97.5.41).

TOWER HH 97.5 SG 5.0-145				
	Section 1 (bottom)	Section 2	Section 3	Section 4 (top)
External diameter upper flange (m)	4.4243	4.4195	4.0159	3.5030
External diameter lower flange (m)	4.6800	4.4243	4.4195	4.0159
Section's height (m)	19.220	21.090	26.290	28.900
Section structural weight (kgs)	64257.2	52845.8	50163.7	46061.4
Section total weight (kgs)	66305.4	53794.9	51346.8	47361.9
Total tower height (m)	**95.500**			
Total tower weight (kg)	**218808.9**			

- Tower hub height 102.5m (4 sections, T102.5.42).

TOWER HH 102.5 SG 5.0-145				
	Section 1 (bottom)	Section 2	Section 3	Section 4 (top)
External diameter upper flange (m)	4.43	4.422	4.017	3.503
External diameter lower flange (m)	4.40	4.43	4.422	4.017
Section's height (m)	19.700	25.300	28.100	27.336
Section structural weight (kgs)	77660.4	70833.2	58363.2	46332.5
Section total weight (kgs)	79730.4	71971.7	59627.7	47562.6
Total tower height (m)	**100.446**			
Total tower weight (kg)	**258893**			

- Tower hub height 102.5m (5 sections, T102.5.43).

TOWER HH 102.5 SG 5.0-145					
	Section 1 (bottom)	Section 2	Section 3	Section 4	Section 5 (top)
External diameter upper flange (m)	4.431	4.424	4.419	4.416	3.503
External diameter lower flange (m)	4.481	4.431	4.424	4.419	4.416
Section's height (m)	14.100	16.900	19.700	25.300	24.434
Section structural weight (kgs)	61263.3	54665.5	49105.0	49175.9	42364.9
Section total weight (kgs)	63239.2	55426.0	49991.5	50314.4	43464.5
Total tower height (m)	**100.434**				
Total tower weight (kg)	**262435.6**				

- Tower hub height 127.5m. Baseline design (6 sections, T127.5.45).

TOWER HH 127.5 SG 5.0-145						
	Section 1 (bottom)	Section 2	Section 3	Section 4	Section 5	Section 6 (top)
External diameter upper flange (m)	4.6550	4.4900	4.4838	4.2698	3.9167	3.5030
External diameter lower flange (m)	4.6800	4.6550	4.4900	4.4838	4.2698	3.9167
Section's height (m)	13.510	17.620	19.955	22.980	24.435	27.000
Section structural weight (kgs)	66214.8	64777.9	62217.4	56958.4	46152.6	43549.4
Section total weight (kgs)	68164.2	65570.8	63115.4	57992.5	47252.2	44764.4
Total tower height (m)	**125.500**					
Total tower weight (kg)	**346859.4**					

- Tower hub height 127.5m. Baseline design (7 sections, T127.5.46).

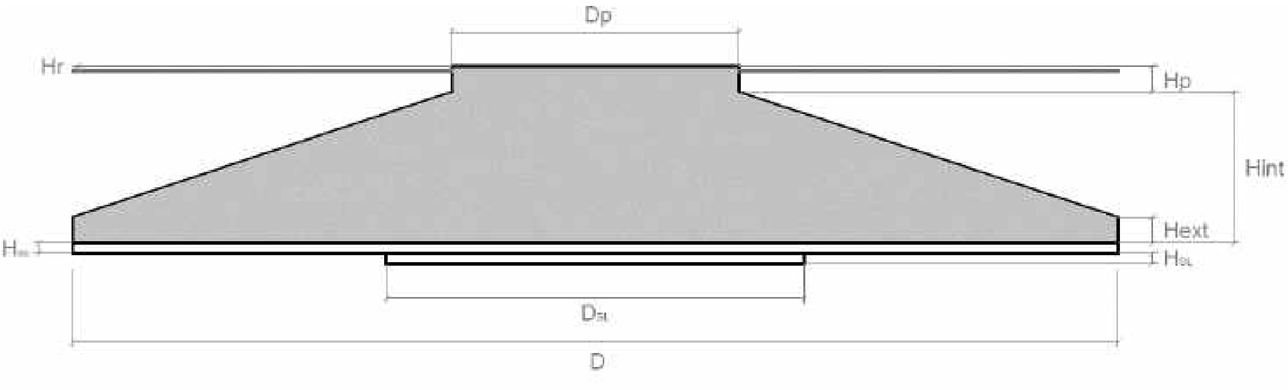
TOWER HH 127.5 SG 5.0-145							
	Section 1 (bottom)	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7 (top)
External diameter upper flange (m)	4.4850	4.486	4.4770	4.4728	4.0900	3.8167	3.503
External diameter lower flange (m)	4.5000	4.4850	4.486	4.4770	4.4728	4.0900	3.8167
Section's height (m)	10.005	11.785	15.095	18.568	22.205	24.845	23.000
Section structural weight (kgs)	54606.8	51948.4	54614.4	54672.8	52405.4	44963.9	36768.1
Section total weight (kgs)	56267.0	52478.7	55293.6	55508.4	53404.6	46081.9	37803.1
Total tower height (m)	**125.503**						
Total tower weight (kg)	**356837.4**						

Information about other tower heights will be available upon request.

Estimated Foundation Design

Hub height: 91 m

Volumes
Concrete volume ~431.22 m³, C30/47 – C40/50 MPa
Reinforcement steel ~39991 kg, B 500 S

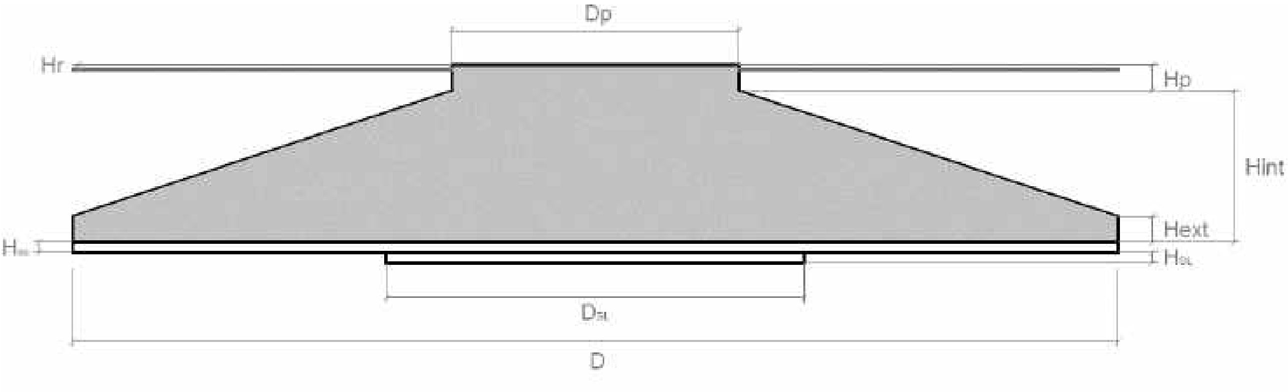


FOUNDATION GEOMETRY	
D= Slab diameter [m]	18.8
Hext= Outter egde height [m]	0.50
Hint= Inner edge height [m]	2.7
Dp= Pedestal diameter [m]	5.50
Hp= Pedestal height [m]	0.50
D_{SL}=Soil improvement diameter [m]	9.5

The estimated foundation design is based on the following assumptions:
- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Hub height: 95.5 m
Volumes
Concrete volume ~453.44 m³, C35/40 – C40/50 MPa
Reinforcement steel ~42921 kg, B 500 S



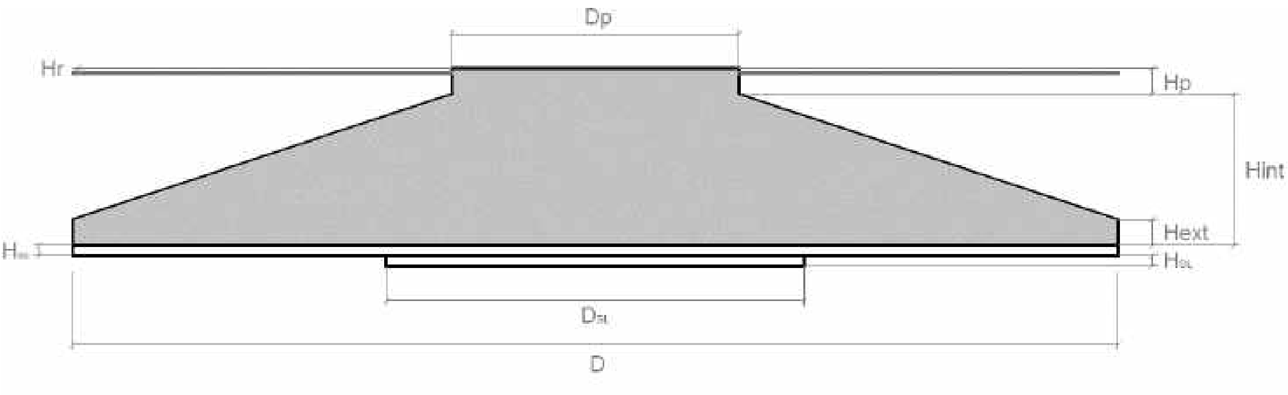
FOUNDATION GEOMETRY	
D= Slab diameter [m]	19.3
Hext= Outter egde height [m]	0.50
Hint= Inner edge height [m]	2.7
Dp= Pedestal diameter [m]	5.6
Hp= Pedestal height [m]	0.50
D_{SL}=Soil improvement diameter [m]	9.1

The estimated foundation design is based on the following assumptions:

- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Hub height: 97.5 m
Volumes
Concrete volume ~455.65 m³, C35/40 – C40/50 MPa
Reinforcement steel ~43295 kg, B 500 S



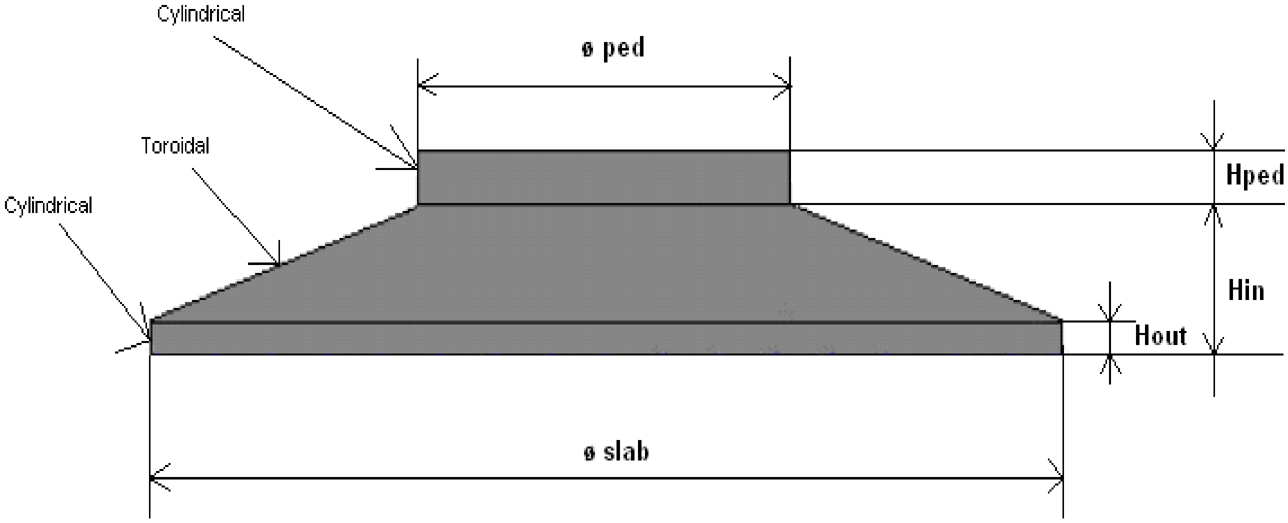
FOUNDATION GEOMETRY	
D= Slab diameter [m]	19.3
Hext= Outter egde height [m]	0.50
Hint= Inner edge height [m]	2.7
Dp= Pedestal diameter [m]	5.70
Hp= Pedestal height [m]	0.50
D_{SL}=Soil improvement diameter [m]	9.4

The estimated foundation design is based on the following assumptions:
- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Hub height: 102.5 m (valid for 4 sections & 5 sections tower options)

Volumes
Concrete volume ~544.50 m³, C35/45 – C40/50 MPa
Reinforcement steel ~50910 kg, B 500 S



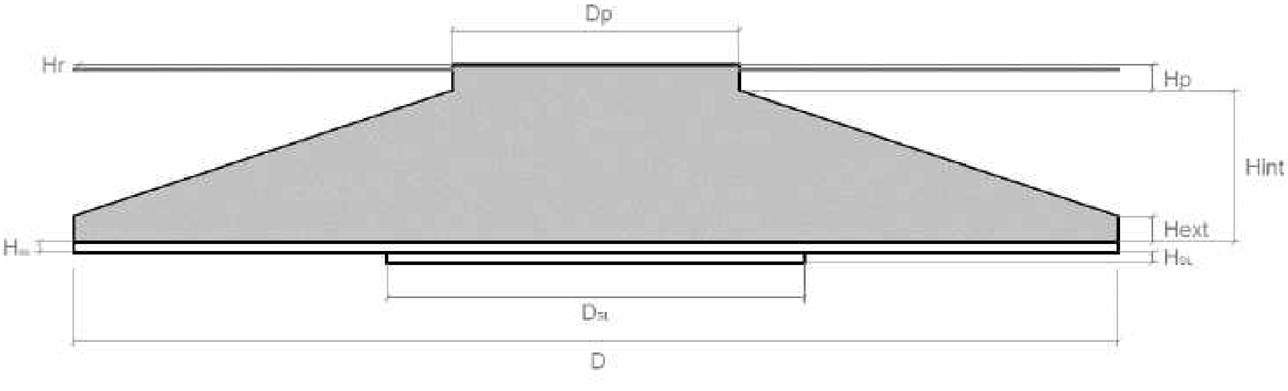
FOUNDATION GEOMETRY	
øslab= Slab diameter [m]	20.8
Hout= Outter egde height [m]	0.50
Hin= Inner edge height [m]	2.9
øped= Pedestal diameter [m]	5.50
Hped= Pedestal height [m]	0.50

The estimated foundation design is based on the following assumptions:
- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Hub height: 127.5 m (T127.5.45)

Volumes
Concrete volume ~547.89 m³, C35/40 – C50/60 MPa
Reinforcement steel ~57783 kg, B 500 S



FOUNDATION GEOMETRY	
D= Slab diameter [m]	21.4
Hext= Outter egde height [m]	0.50
Hint= Inner edge height [m]	2.7
Dp= Pedestal diameter [m]	5.70
Hp= Pedestal height [m]	0.50
D_{SL}=Soil improvement diameter [m]	9.3

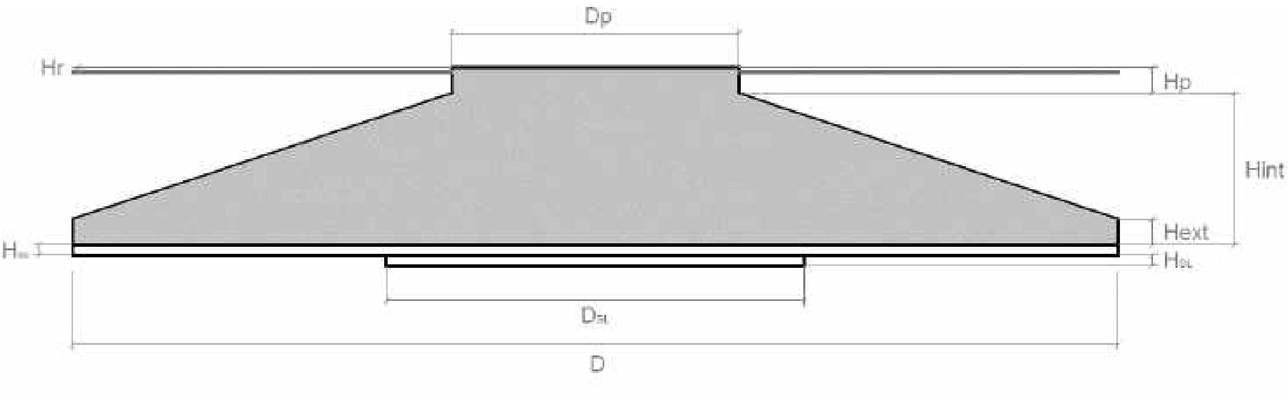
The estimated foundation design is based on the following assumptions:

- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Hub height: 127.5 m (T127.5.46)

Volumes
Concrete volume ~545.47 m³, C35/40 – C50/60 MPa
Reinforcement steel ~57783 kg, B 500 S



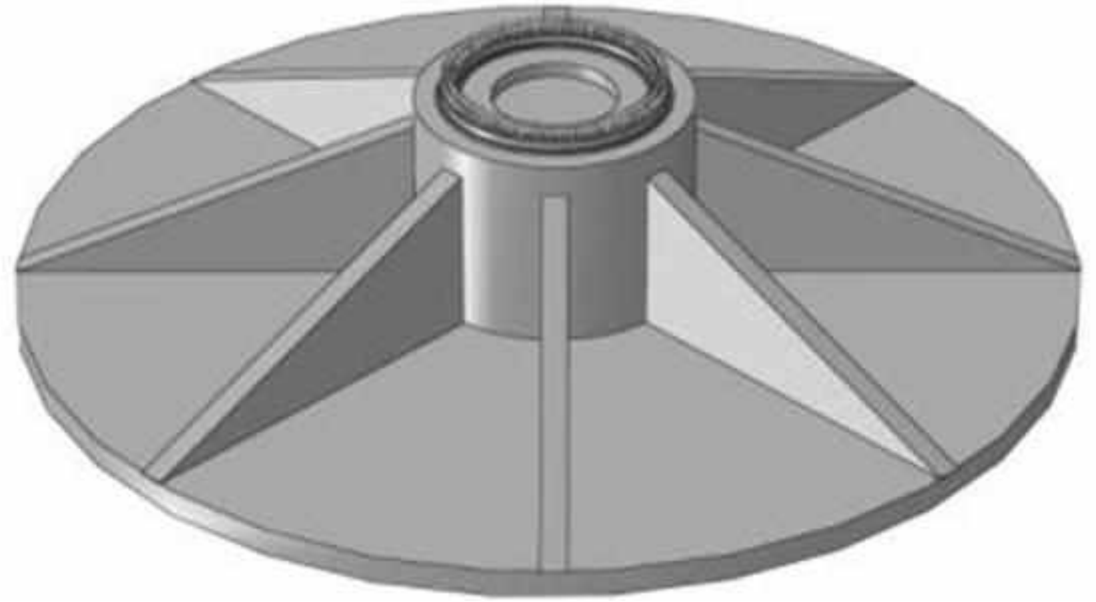
FOUNDATION GEOMETRY	
D= Slab diameter [m]	21.4
Hext= Outter egde height [m]	0.50
Hint= Inner edge height [m]	2.7
Dp= Pedestal diameter [m]	5.60
Hp= Pedestal height [m]	0.50
D_{SL}=Soil improvement diameter [m]	9.3

The estimated foundation design is based on the following assumptions:
- Gravity based flat foundation without buoyancy
- Specific weight of backfill 18.0 kN/m³
- Friction angle 30.0°

Additional factors that may impact the foundation design:
Soil conditions, country, designer practice, national codes and standards.

Although the standard and most common foundation concept is the previously shown circular tapered slab, it is also possible to design, based on site specific conditions, the optimized “8 Walls foundation”.

See figure below:



Preliminary Grid Performance Specification, 50 Hz

General

This document describes the grid performance of the SG 5.0-145, 50 Hz wind turbine. Siemens Gamesa Renewable Energy (SGRE) will provide wind turbine technical data for the developer to use in the design of the wind power plant and the evaluation of requirements compliance. The developer will be responsible for the evaluation and ensuring that the requirements are met for the wind power plant.

The capabilities described in this document are based on the assumption that the electrical network is designed to be compatible with operation of the wind turbine. SGRE will provide a document with guidance to perform an assessment of the network's compatibility.

Fault Ride Through (FRT) Capability

The wind turbine is capable of operating when voltage transient events occur on the interconnecting transmission system above and below the standard voltage lower limits and time slot according to Figure 1 and Figure 2.

This performance assumes that the installed amount of wind turbines is in the right proportion to the strength of the grid, which means that the short circuit ratio (Sk/Sn) and the X/R ratio of the grid at the wind turbine transformer terminals must be adequate.

Evaluation of the wind turbine's fault ride through capability in a specific system must be based on simulation studies using the specific network model and a dynamic wind turbine model provided by SGRE in PSS/E. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the SG 5.0-145, 50 Hz wind turbine are presented in Figure 1 between 100 -1000 seconds and in Figure 2 between 0 – 12 seconds.

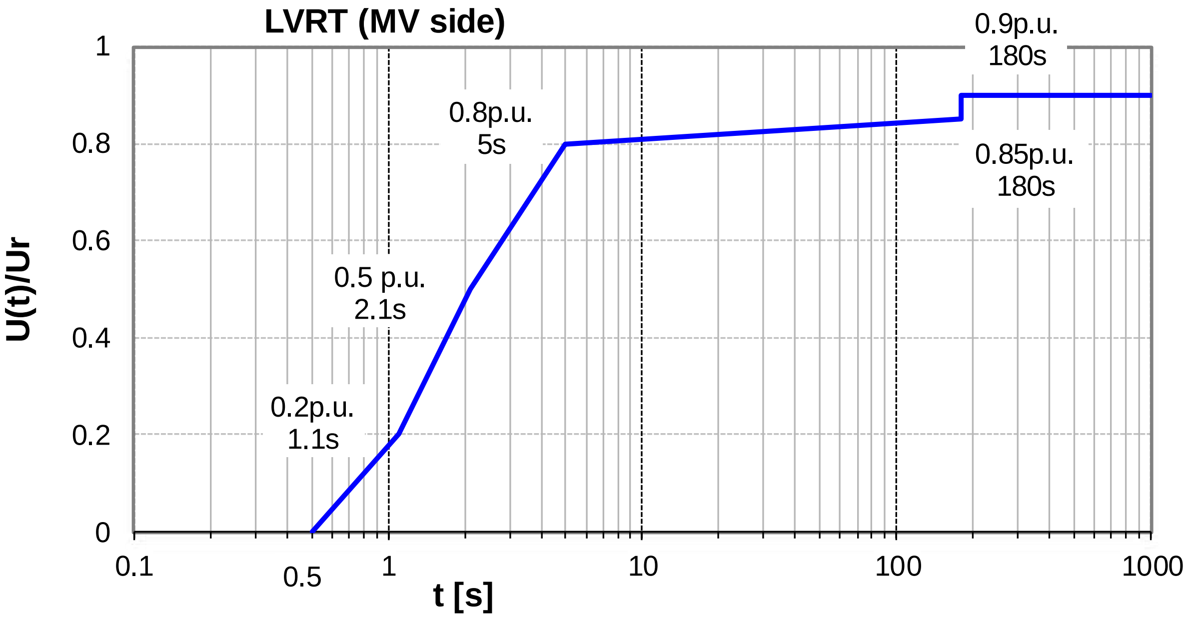


Figure 1. Lower voltage limits for SG 5.0-145, 50 Hz wind turbine in the range of 0-1000 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

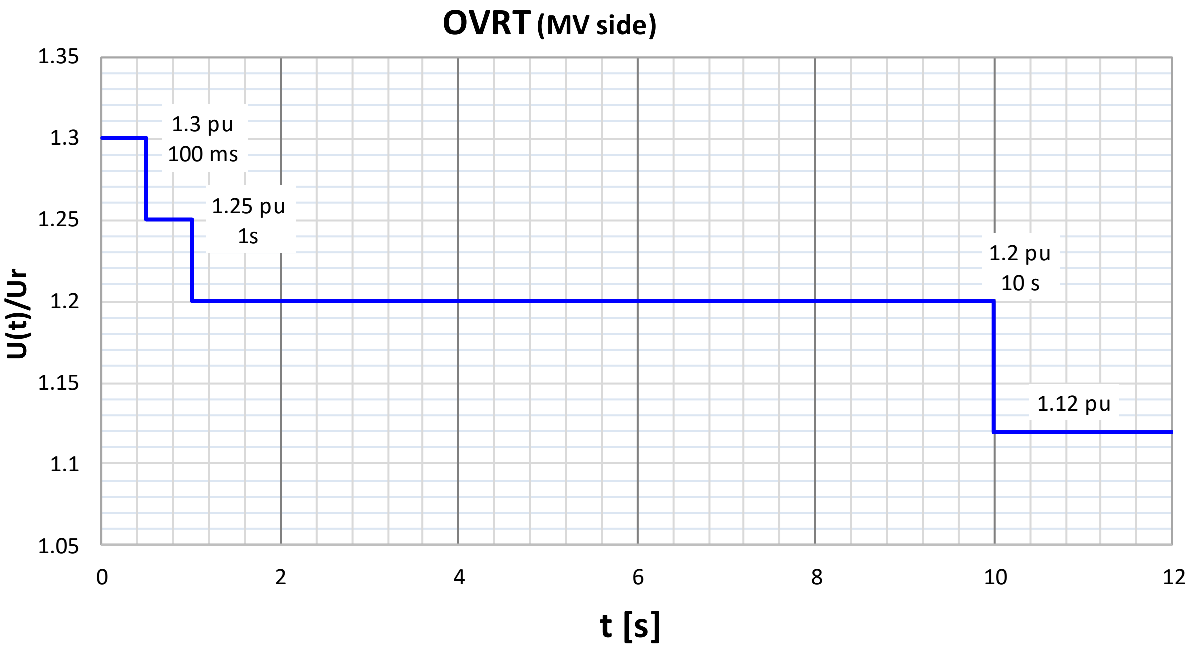


Figure 2. Upper voltage limits for SG 5.0-145, 50 Hz wind turbine in the range of 0-12 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

Power Factor (Reactive Power) Capability
The wind turbine is able to operate in a power factor range of 0.9 leading to 0.9 lagging at the low voltage side of the wind turbine transformer, at nominal balanced voltage and nominal frequency. The control mode for the wind turbine is with reactive power set-points.

Supervisory Control and Data Acquisition (SCADA) Capability
The SGRE SCADA system has the capability to transmit and receive instructions from the transmission system provider for system reliability purposes depending on the configuration of the SCADA system. The project specific SCADA requirements must be specified in detail for design purposes.

Frequency Capability
The wind turbine is able to operate in the frequency range between 47 Hz and 53 Hz.

Voltage Capability
The voltage operation range for the wind turbine is between 90% and 112% of nominal voltage at the low voltage side of the wind turbine transformer. The voltage can be up to 130% for 100ms, see Figure 2. The wind turbine's target voltage shall stay between 95% and 105% in order to support the best possible performance by staying within the operation limits.

Flicker and Harmonics
Flicker and Harmonics values will be provided in the power quality measurement report extract in accordance with IEC 61400-21 Edition 2.

Reactive Power -Voltage Control
The power plant controller can operate in four different modes:

- Q Control – In this mode reactive power is controlled at the point of interconnection, according to a reactive power reference
- V Control – Voltage is directly controlled at the point of interconnection, according to a voltage reference
- V-Q static – Voltage is controlled at the point of interconnection, by means of a pre-defined voltage – reactive power characteristic
- Power factor (cosphi) control – Power factor is controlled at the point of interconnection, according to a power factor reference

The SCADA system receives feedback/measured values from the Point Of Interconnection depending on the control mode it is operating. The wind power plant controller then compares the measured values against the target levels and calculates the reactive power reference. Finally, reactive power references are distributed to each individual wind turbine. The wind turbine's controller responds to the latest reference from the SCADA system and will generate the required reactive power accordingly from the wind turbine.

Frequency Control
The frequency control is managed by the SCADA system together with the wind turbine controller. The wind power plant frequency control is carried out by the SCADA system which distributes active power set-points to each individual wind turbine, to the controllers. The wind turbine controller responds to the latest reference from the SCADA system and will maintain this active power locally.

All data are subject to tolerances in accordance with IEC.

Preliminary Grid Performance Specification, 60 Hz

General

This document describes the grid performance of the SG 5.0-145, 60 Hz wind turbine. Siemens Gamesa Renewable Energy (SGRE) will provide wind turbine technical data for the developer to use in the design of the wind power plant and the evaluation of requirements compliance. The developer will be responsible for the evaluation and ensuring that the requirements are met for the wind power plant.

The capabilities described in this document are based on the assumption that the electrical network is designed to be compatible with operation of the wind turbine. SGRE will provide a document with guidance to perform an assessment of the network's compatibility.

Fault Ride Through (FRT) Capability

The wind turbine is capable of operating when voltage transient events occur on the interconnecting transmission system above and below the standard voltage lower limits and time slot according to Figure 3 and Figure 4.

This performance assumes that the installed amount of wind turbines is in the right proportion to the strength of the grid, which means that the short circuit ratio (Sk/Sn) and the X/R ratio of the grid at the wind turbine transformer terminals must be adequate.

Evaluation of the wind turbine's fault ride through capability in a specific system must be based on simulation studies using the specific network model and a dynamic wind turbine model provided by SGRE in PSS/E. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the SG 5.0-145, 60 Hz wind turbine are presented in Figure 3 between 100 -1000 seconds and in Figure 4 between 0 – 12 seconds.

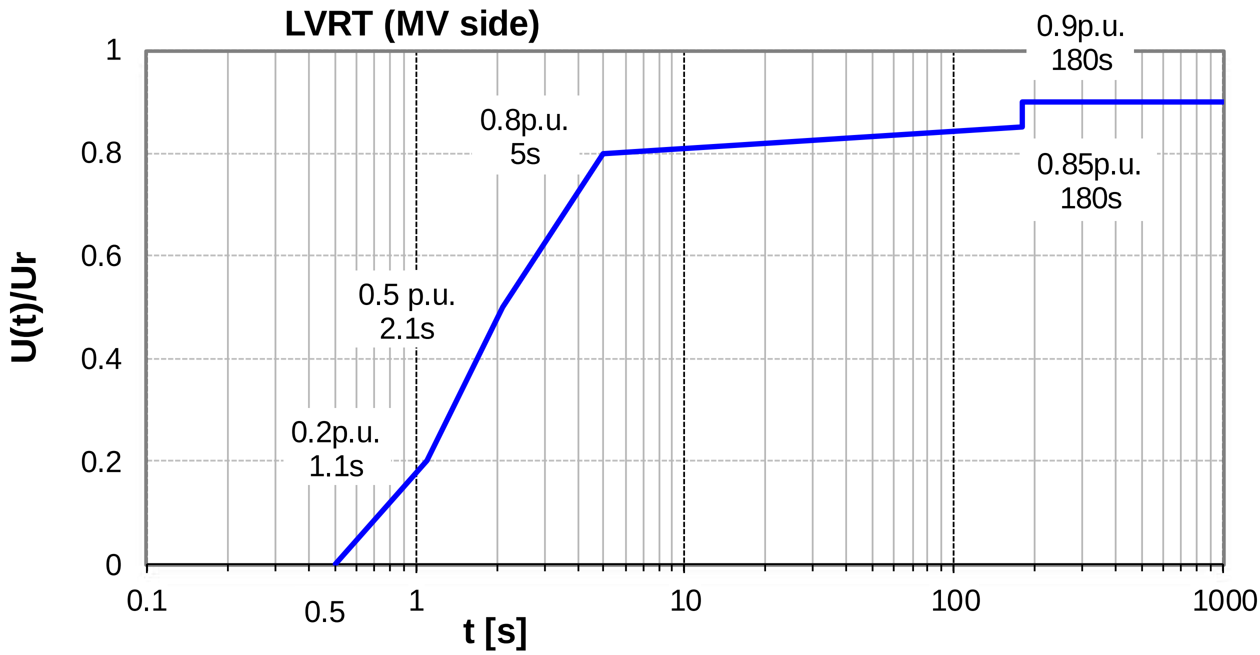


Figure 3. Lower voltage limits for SG 5.0-145, 60 Hz wind turbine in the range of 0-1000 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

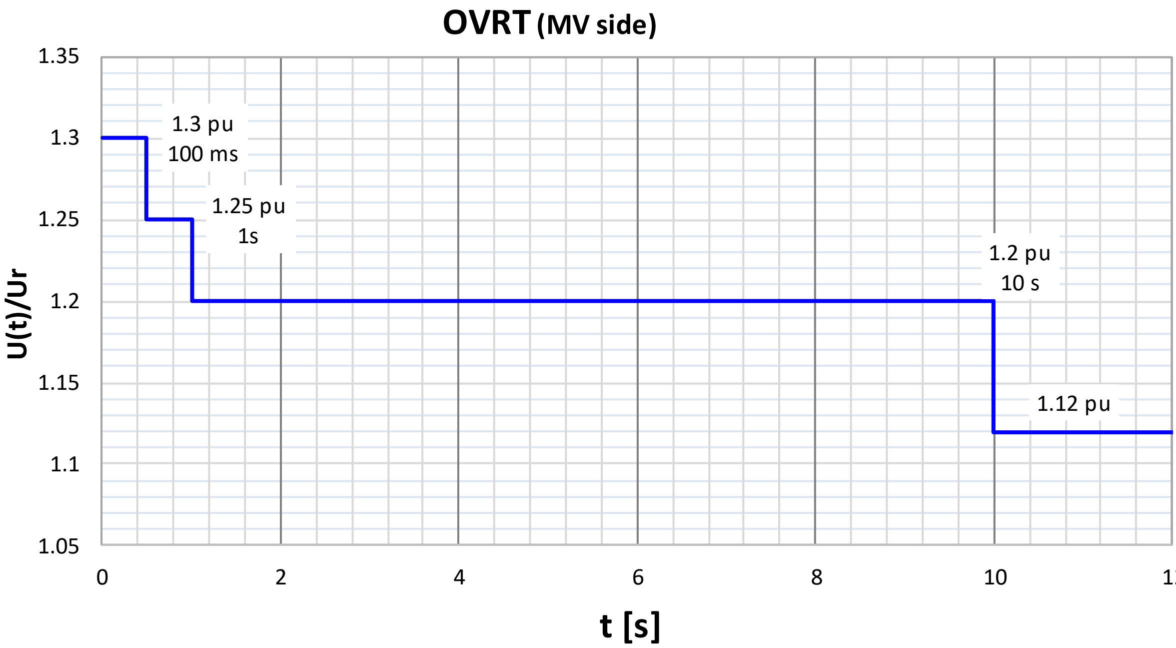


Figure 4. Upper voltage limits for SG 5.0-145, 60 Hz wind turbine in the range of 0-12 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

Power Factor (Reactive Power) Capability
The wind turbine is able to operate in a power factor range of 0.9 leading to 0.9 lagging at the low voltage side of the wind turbine transformer, at nominal balanced voltage and nominal frequency. The control mode for the wind turbine is with reactive power set-points.

Supervisory Control and Data Acquisition (SCADA) Capability
The SGRE SCADA system has the capability to transmit and receive instructions from the transmission system provider for system reliability purposes depending on the configuration of the SCADA system. The project specific SCADA requirements must be specified in detail for design purposes.

Frequency Capability
The wind turbine is able to operate in the frequency range between 56.4 Hz and 63.6 Hz.

Voltage Capability
The voltage operation range for the wind turbine is between 90% and 112% of nominal voltage at the low voltage side of the wind turbine transformer. The voltage can be up to 130% for 100ms, see Figure 4. The wind turbine's target voltage shall stay between 95% and 105% in order to support the best possible performance by staying within the operation limits

Flicker and Harmonics
Flicker and Harmonics values will be provided in the power quality measurement report extract in accordance with IEC 61400-21 Edition 2.

Reactive Power -Voltage Control
The power plant controller can operate in four different modes:

- Q Control – In this mode reactive power is controlled at the point of interconnection, according to a reactive power reference
- V Control – Voltage is directly controlled at the point of interconnection, according to a voltage reference
- V-Q static – Voltage is controlled at the point of interconnection, by means of a pre-defined voltage – reactive power characteristic
- Power factor (cosphi) control – Power factor is controlled at the point of interconnection, according to a power factor reference

The SCADA system receives feedback/measured values from the Point Of Interconnection depending on the control mode it is operating. The wind power plant controller then compares the measured values against the target levels and calculates the reactive power reference. Finally, reactive power references are distributed to each individual wind turbine. The wind turbine's controller responds to the latest reference from the SCADA system and will generate the required reactive power accordingly from the wind turbine.

Frequency Control
The frequency control is managed by the SCADA system together with the wind turbine controller. The wind power plant frequency control is carried out by the SCADA system which distributes active power set-points to each individual wind turbine, to the controllers. The wind turbine controller responds to the latest reference from the SCADA system and will maintain this active power locally.

All data are subject to tolerances in accordance with IEC.

Reactive Power Capability, 50 Hz

General
This document describes the reactive power capability of SG 5.0-145, 50 Hz wind turbines during active power production. SG 5.0-145 wind turbines are equipped with a B2B Partial load frequency converter which allows the wind turbine to operate in a wide power factor range.

Reactive Power Capability Curves

The reactive power capability for the wind turbine at the LV side of the wind turbine transformer will be presented in the following Figures.

Figure 5 shows the reactive power capability on the LV side of the wind turbine depending on the generated power at LV terminals.

Figure 6 shows the reactive power capability on the LV side of the wind turbine transformer at various voltages between 0.90 p.u. and 1.13 p.u. at the LV terminals.

Figure 7 includes reactive power capability at no wind (QwP0).

The SCADA can send voltage references to the wind turbine in the range of 0.92 p.u. to 1.08 p.u. The wind power plant should be designed to maintain the wind turbine voltage references between 0.95 p.u. and 1.05 p.u. during steady state operation.

The tables and figures assume that the phase voltages are balanced, and that the grid operational frequency and component values are nominal. Unbalanced voltages will decrease the reactive power capability. Component tolerances were not considered in determining curve parameters. Instead, the curves and data are subject to an overall tolerance of ± 5 % of the rated power.

The reactive power capability presented in this document is the net capability and accounts for the contribution from the wind turbine auxiliary system, the reactor and the filter.

The reactive power capability described is valid while operating the wind turbine within the limits specified in the Design Climatic Conditions.

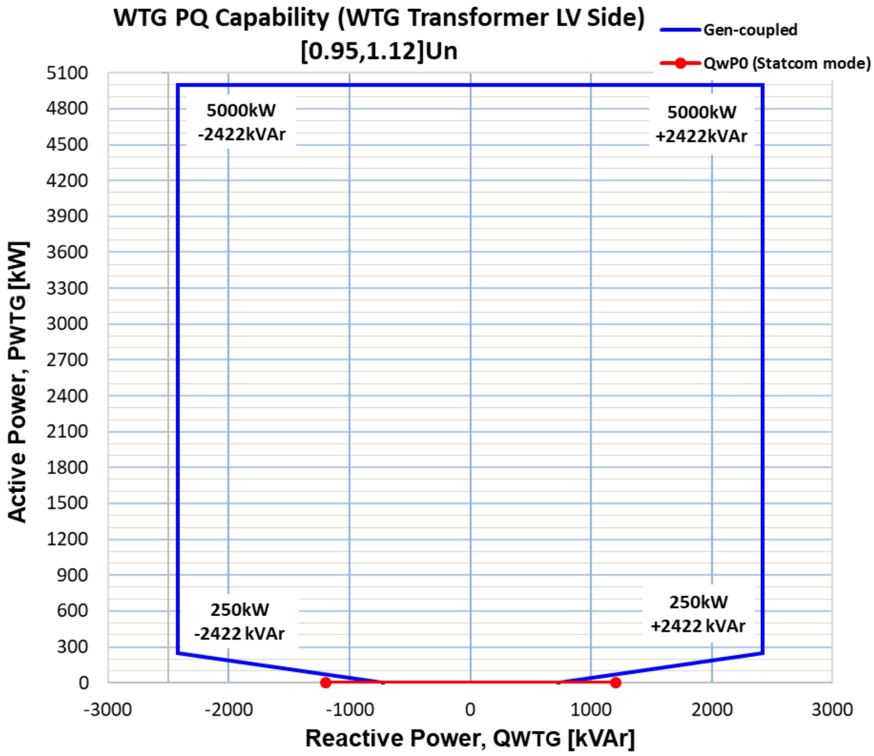


Figure 5: Reactive power capability curves, 50 Hz wind turbine, at LV side of wind turbine transformer.

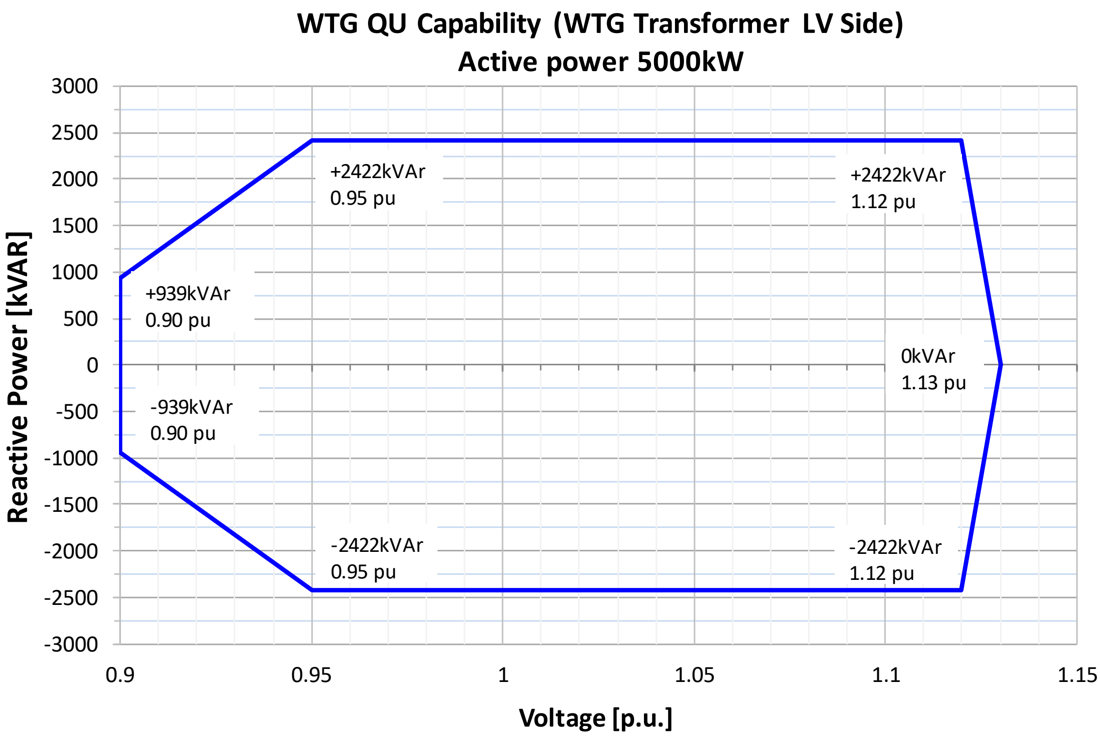


Figure 6. Reactive power capability versus voltage.

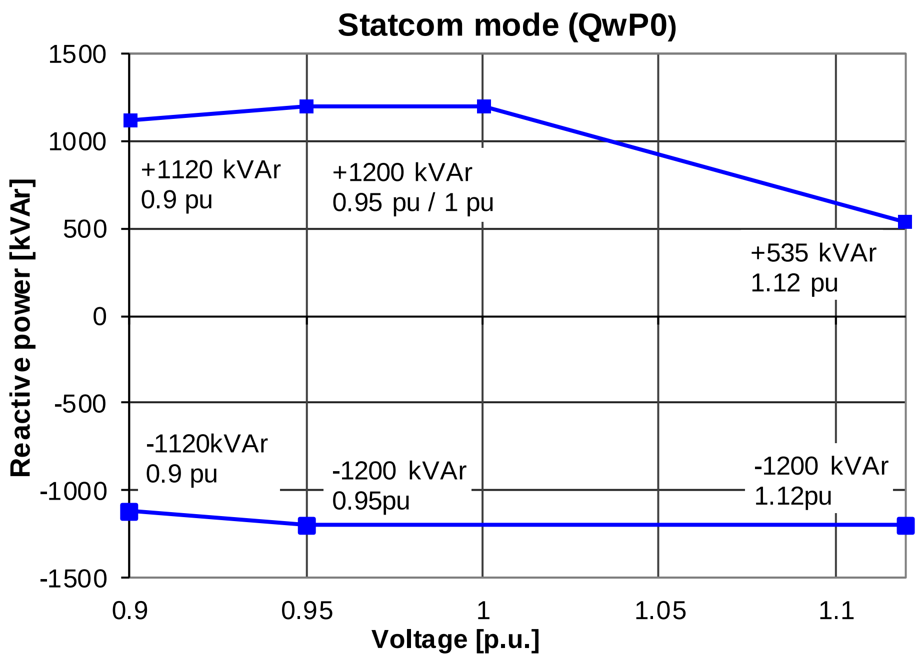


Figure 7. Reactive power capability at no wind (QwP0)

All data are subject to tolerances in accordance with IEC.

Reactive Power Capability, 60 Hz

General
This document describes the reactive power capability of SG 5.0-145, 60 Hz wind turbines during active power production. SG 5.0-145 wind turbines are equipped with a B2B Partial load frequency converter which allows the wind turbine to operate in a wide power factor range.

Reactive Power Capability Curves
The reactive power capability for the wind turbine at the LV side of the wind turbine transformer will be presented in the following Figures.

Figure 8 shows the reactive power capability on the LV side of the wind turbine depending on the generated power at LV terminals.

Figure 9 shows the reactive power capability on the LV side of the wind turbine transformer at various voltages between 0.90 p.u. and 1.13 p.u. at the LV terminals.

Figure 10 includes reactive power capability at no wind (QwP0).

The SCADA can send voltage references to the wind turbine in the range of 0.92 p.u. to 1.08 p.u. The wind power plant should be designed to maintain the wind turbine voltage references between 0.95 p.u. and 1.05 p.u. during steady state operation.

The tables and figures assume that the phase voltages are balanced, and that the grid operational frequency and component values are nominal. Unbalanced voltages will decrease the reactive power capability. Component tolerances were not considered in determining curve parameters. Instead, the curves and data are subject to an overall tolerance of ± 5 % of the rated power.

The reactive power capability presented in this document is the net capability and accounts for the contribution from the wind turbine auxiliary system, the reactor and the filter.

The reactive power capability described is valid while operating the wind turbine within the limits specified in the Design Climatic Conditions.

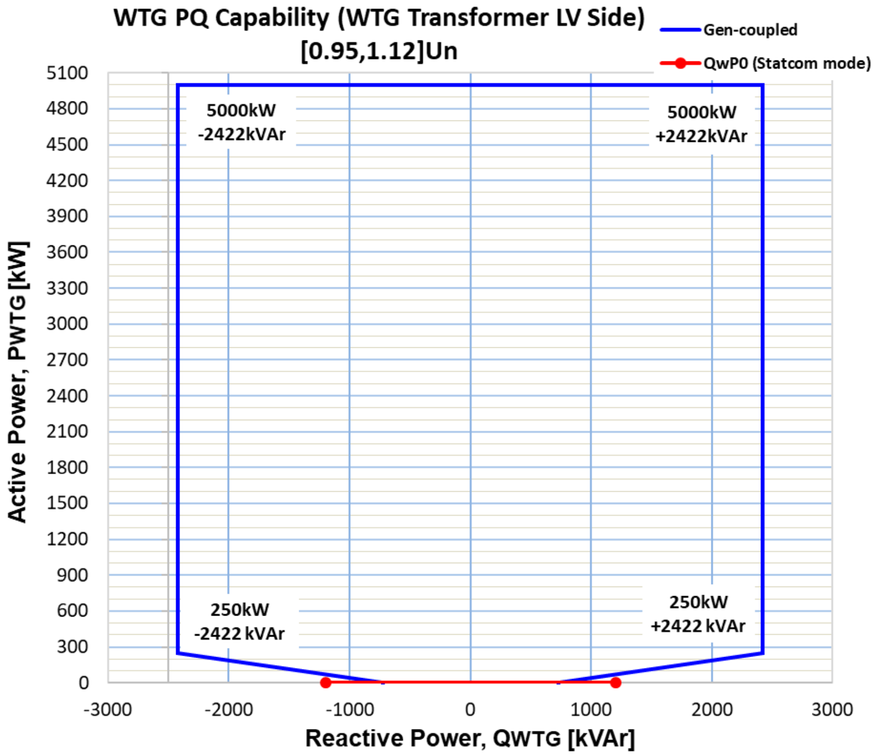


Figure 8. Reactive power capability curves, 60 Hz wind turbine, at LV side of wind turbine transformer

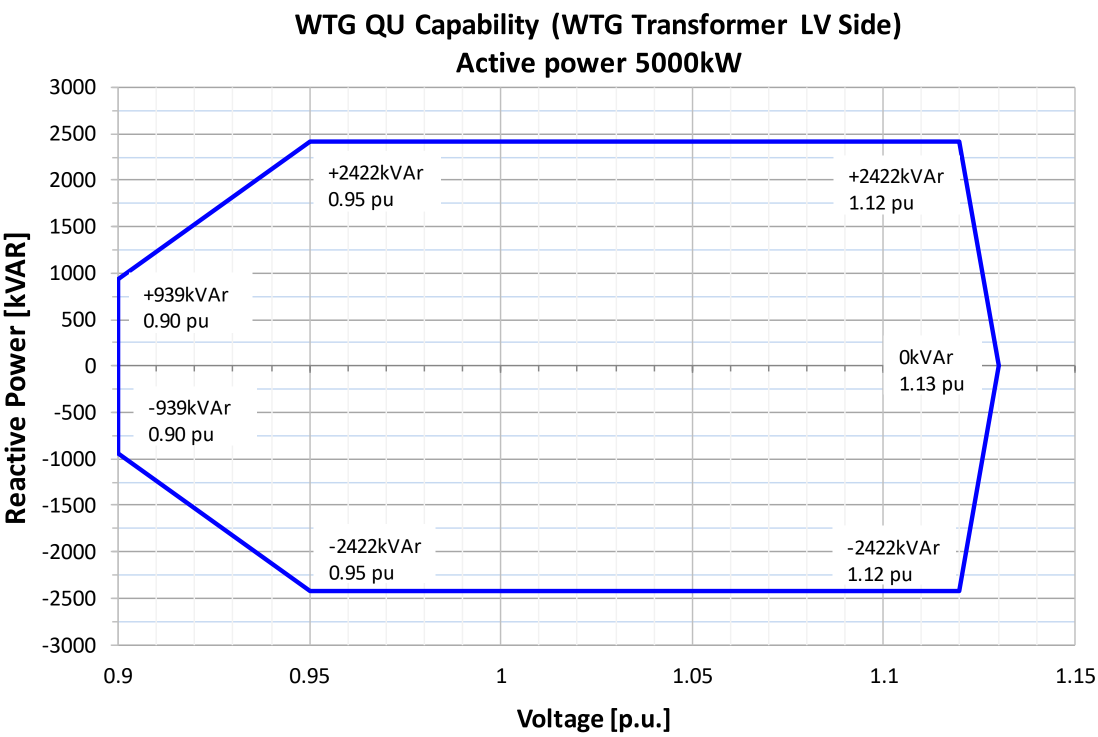


Figure 9. Reactive power capability versus voltage

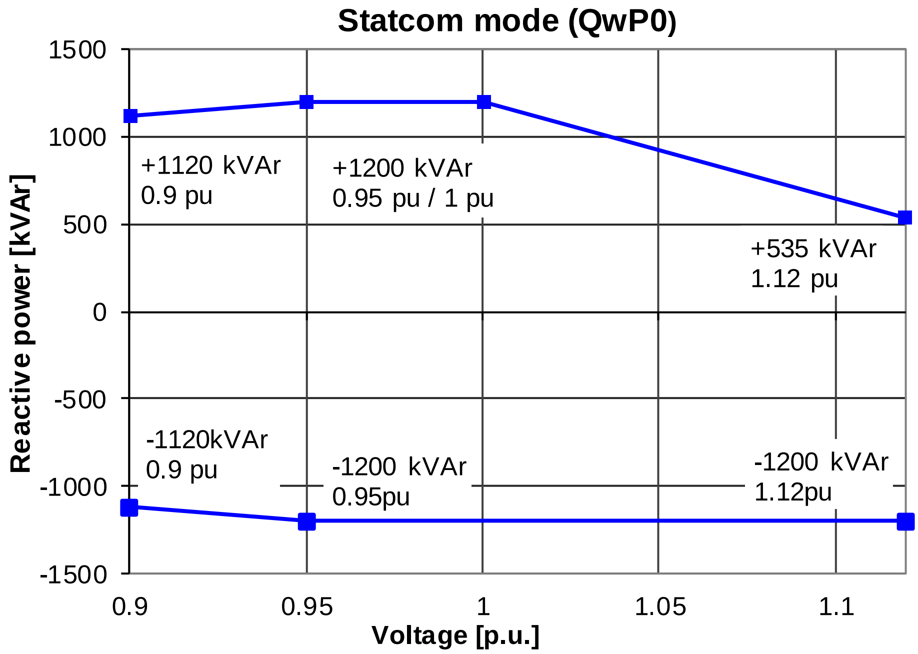


Figure 10. Reactive power capability at no wind (QwP0).

SCADA, System Description

General

This is a general description of the Siemens Gamesa Renewable Energy (SGRE) SCADA System.

SGRE SCADA system is a wind farm management tool. Overall, the SCADA enables:

- Supervising, monitoring and/or controlling SGRE wind turbines in a given wind farm,
- Monitoring of wind farm components such as meteorological masts, substations, measuring devices, etc.
- Storing and managing information, which provides an advanced capacity to generate reports.
- Connecting to control centers or higher level management systems.
- Wind farm power regulation for both active as well as reactive power.
- Wind farm electricity generation based on environmental conditions.

In short, the SGRE SCADA system is an indispensable communications gateway for incoming and outgoing wind farm data.

Main Features

The SGRE SCADA system has the following main features:

- Wind turbine supervision and control.
- Meteorological mast supervision.
- Monitoring of the wind farm's feed-in substation.
- Alarms and notifications SGRE management.
- Reporting for technical and economic wind farm exploitation.
- Access security via user and profile management.
- Multiple-wind farm management capacity enabling various wind farms to be managed from a single SCADA installation. Optimized SQL database for data management.
- Integration with a preventive maintenance system (PMS)
- Additionally, the SGRE SCADA system has the following optional features:
- Data server for access and/or integration in upper systems: OPC-UA server and IEC104 server.
- Integration of the SGRE Power Manager tool, which includes the active power/frequency regulating tools and reactive power/voltage regulation for the wind farm
- NRS® (Noise Reduction System) to safeguard the acoustic integrity of the area based on wind direction and time
- Shadow Control System to prevent the undesired effects of shadows in residential areas near the wind farm
- Wake Cancellation System for protecting wind turbines from intense turbulence based on wind direction
- Ice Detection System for protecting the surrounding area against ice thrown from wind turbine blades
- Bat Shield System for protecting bats
- Bird Detection System for protecting birds
- Alarm Notification application for distributing SMS and/or email messages to operators and maintenance technicians (SIM card not included)
- ODBC access to the database.

Wind Farm Management System

SGRE's wind farm management system comprises the central system, Service Operations Center (SOC), the SCADAs installed in wind farms and the wide area network (WAN) that links them all together.

During maintenance and/or the warranty period, wind farms with SGRE wind turbines must be integrated in SGRE's central system under the control of the SOC (Service Operations Center). This system compiles data from all connected wind farms, checking and storing the retrieved data in keeping with the specified storage policy. The centralization of wind farm supervision offers excellent resources for monitoring the product, maintenance planning and reports on operating status and maintenance intended for clients.

External access to the wind farm from SGRE's central system requires communication line supplied by the Employer. Nonetheless, other communications solutions can be assessed whenever they meet the technical requirements for communications specified by SGRE.

Communication Network in Wind Farm

A wind farm's internal communications infrastructure is a network that links the SGRE SCADA system to the various wind farm devices (e.g., wind turbines, meteorological masts and substations).

Internal wind farm communications are based on a local area network (LAN) with Ethernet communications on ring-configured fiber optics. This is a "logical" round-trip ring through the same fiber optic cable so that the send path runs through two fibers and the return path runs through another two in the same cable. The wind turbines alternate where fibers connect to one another in the routing to prevent long links whenever possible.

The selection of the fiber optics for the wind farm and the overall layout of the ring network must meet SGRE specifications and will always be defined or validated by SGRE.

Likewise, the final configuration of a specific LAN network for a given wind farm will be jointly agreed between SGRE and the wind farm client.

External communication outside the wind farm through external protocols and/or SCADA clients can be based on any type of telecommunications system such as satellite links, ADSL/DSL lines, GPRS links, PSTN modems, GSM modems, etc. The primary criteria for selecting the appropriate means are the bandwidth requirements, need for continuous or on-demand connection, and the amount of data exchanged.

Client Interface

Wind farm operators can view all the data in a simple and intuitive user interface based on web browser technology.

All operational aspects and access to SCADA system options are available through a standard web browser.

Data Analysis

SGRE SCADA system includes 3 different wind farm data analysis tools:

- Reports: designed for exploitation reports
- Trending: designed for in-depth analysis of wind turbine variables.

Comparatives: designed for instantaneously comparing two variables of all the wind turbines in the farm.

Codes and Standards

The wind turbine is designed and certified with an external certification body according to:

- IEC 61400-1:2005 +AMD1:2010 Edition 3 - Wind turbines - Part 1: Design requirements
- IEC 61400-22:2010 Edition 1 - Wind turbines – Part 22: Conformity testing and certification
- ISO 9001:2015 - Quality management systems – Requirements.
- Directive 2006/42/CE - Machinery (MD)

Other Performance Features

Siemens Gamesa Renewable Energy (SGRE) offers the following optional performance features for SG 5.0-145 that can optimize your wind farm by boosting performance, enhancing environmental agility, supporting compliance with legal regulation, and supporting grid stability.

Flexible Rating

In order to have the best product and solution for our clients, the SG 5.0-145 wind turbine is designed to integrate the OptimaFlex philosophy: a design strategy that provides a high degree of adaptability, including several power rating options and possibilities for tower optimization.

Inside the OptimaFlex philosophy, Flexible Rating strategy has been designed to allow modifying the turbine rated power depending on project specific conditions related to temperature, electrical requirements and mechanical loads. This feature is optional and applicability depends on the fulfilment of the defined temperature, electrical and mechanical loads requirements.

The SG 5.0-145 wind turbine can be configured to operate with a flexible power rating, enabling site specific optimization. It is designed to work at 5.0 MW rated power as baseline, but additional ratings are also available under certain project and environmental conditions.

In the SG 5.0-145 Flexible Rating strategy, different Application Modes (AM) with different power ratings are available. Each Application Mode is associated with a specific set of performance conditions.

Flexible Rating application procedure and concept:

- Upfront analysis: If Flexible Rating optional strategy wants to be enabled, an upfront analysis is needed for each project in order to define which is the maximum Application Mode admissible considering the specific site mechanical loads and general grid requirements.

- Wind turbine operation: Flexible Rating controller algorithm dynamically defines which is the active power than can be delivered depending on the ambient temperature and grid demands, always limited by the maximum Application Mode defined in the upfront analysis for each site. Temperature and reactive power demand is prioritized. If grid demands higher reactive power (Q) than the one allowed for an AM, active power (P) will be decreased.

In the following table, a summary of the SG 5.0-145 Flexible Rating strategy is presented.

AM	Rated power	Wind Conditions [1]	Maximum Temperature (full power operation) [2]	Maximum Temperature (with power derating) [3]	Electrical performance limits	Maximum Noise Emission level [dB(A)] [4]
AM+1	5.2 MW	Less demanding wind conditions	+20.0ºC	+45ºC	cos PHI 0.95 @[0.95,1.12]Un @±2%frequency	106.3
AM0	**5.0 MW**	**IIB**	**+25.0ºC**	**+45ºC**	cos PHI 0.9 @[0.95,1.12]Un @±3%frequency	**106.3**
AM-1	4.9 MW	More demanding wind conditions	+30.0ºC	+45ºC		106.3
AM-2	4.8 MW		+35.0ºC	+45ºC		106.3
AM-3	4.7 MW		+36.6ºC	+45ºC		106.3
AM-4	4.6 MW		+38.3ºC	+45ºC		106.3
AM-5	4.5 MW		+40.0ºC	+45ºC		106.3
AM-6	4.2 MW		+41.0ºC	+45ºC		106.3
AM-7	4.0 MW		+41.6ºC	+45ºC		106.3
AM-8	3.0 MW		+44.0ºC	+45ºC		106.3

[1] Each “Application Mode” is associated with a specific set of wind conditions.
[2] Maximum external ambient temperature outside nacelle, for altitudes below 1000m, full power operation.
[3] Maximum external ambient temperature outside nacelle, for altitudes below 1000m, with power deraring. Operation maximum temperature is extended up to +45ºC including “Power Derating due to external ambient temperature and altitude” feature. See section “Other Performance Features” for further information.
[4] Noise values presented correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade. The turbine can be supplied without noise reduction add-ons, if required, without impacting in the other performance parameters.

DFIG Premimum Converter

The DFIG Premium Converter improves turbine performance in weak grids and assures compliance with the most stringent grid codes. It has an enhanced control in weak grids, regulating the behavior of the wind turbine and reacting to static and transient events while ensuring grid stability.

Optional functionalities available upon request to ensure optimal suitability to site conditions:

- Extended High Voltage Ride Through.
- Enhanced Low Voltage Ride Through
- Series Compensation Compatibility.
- Anti-islanding.
- Turbine operation in grids with Short Circuit Ratio (SCR) as low as 1.5.

Concept	Description	Premium Converter
HVRT Extended	Extended HVRT profile (from 1.1pu to 1.5pu)	✓
LVRT Enhanced	Reactive current control in asymmetrical faults	✓
Series Compensation Compatibility	Control of Sub-Synchronous resonance events	✓
Anti-islanding	Detection of islanding events and controlled disconnection	✓
Low SCR* (<3)	Operation in weak grids	✓

*SCR at turbine connection point is subject to grid conditions at project site.

High Wind Derated operational mode

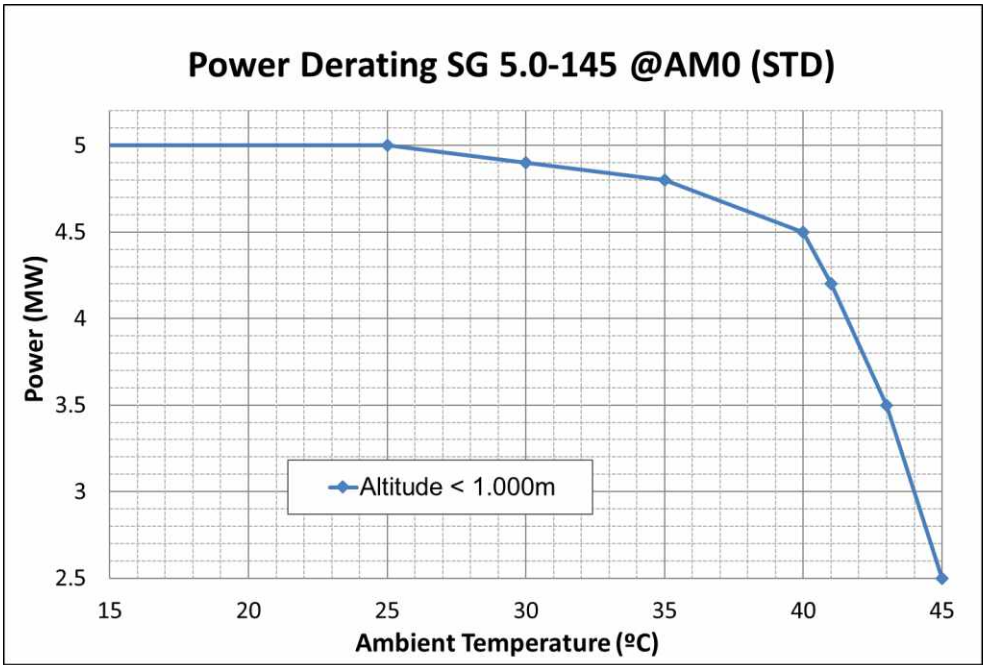
In the case of SG 5.0-145 high wind derated mode, it is enabled by default as it can be observed on the different power curves included in this document. The power production is limited once the wind speed exceeds a threshold value defined by design, until cut-out wind speed is reached and the wind turbine stops producing power. This functionality extends the range of operation in high wind conditions, limiting turbine loads dependent of maximum operational wind speed, providing more predictable energy output, minimizing production losses, and improving grid stability by reducing the risk of simultaneous power cut outs.

High Temperature Derated operational mode (also known as Power Derating due to external temperature and altitude)

Ventilation and cooling systems are designed to allow the turbine operation at rated power up to a certain external nominal temperature and a certain altitude. For sites located beyond 1000m above the sea level, the air density reduction affects the turbine components ventilation capacity, reducing the maximum operational temperature at rated power. However, this maximum ambient temperature can be extended by reducing the delivered power with the temperature derated mode.

Considering the individual component requirements in temperatures at different altitude levels, and their dissipated heat at different power limits, several power-temperature curves are generated. These curves define the envelopes inside which the SG 5.0-145 can operate assuring the integrity of all components.

Next chart shows the power output as a function of the external temperature for an altitude at hub height of up to 1.000m (AM0). Additional information about other altitudes or Application Modes (AM) is available upon request.



The control system, considering the turbine thermal variant and altitude above sea level, will dynamically adjust the maximum allowed power as a function of the ambient temperature.

Ice Detection System

A default Ice Detection System (IDS) is included in SG 5.0-145. This system is required in order to prevent the turbine operating under non desirable ice conditions that could represent an out-of-design situation with risk for the turbine integrity or H&S.

The default Ice Detection System can be improved by application of additional features, described as follows:

- Ice on nacelle sensor (optional kit). Additional sensor is installed to detect ice on nacelle.

Adaptative Operation under ice conditions (comercially presented as "OWI 2.0")

An optional controller algorithm is available in the SG 5.0-145 to improve performance under ice conditions without requiring additional hardware modifications.

In the case of ice build up on blades, the wind turbine performance is reduced and blades can be under stall conditions. The basis of this algorithm is to have an adaptative operation that finds the optimal operational setting through pitch angle and rotational speed modifications, for maximum power production on icing conditions without exceeding the load capabilities of the wind turbine.

Noise Reduction System

The Noise Reduction System (NRS) is an optional module available with the basic SCADA configuration and it therefore requires the existence of a SGRE SCADA system to work.

The purpose of this system is to limit the noise emitted by any of the functioning turbines and thereby comply with local regulations regarding noise emissions. This allows wind farms to be located closer to urban areas, limiting the environmental impact that they imply.

Bat Protection System

To support the installation of wind turbines in areas that constitute a natural habitat for bats, SGRE has developed a Bat Protection System. Bats are usually more active at certain times of the night and at certain times of the year, depending on the local habitat and/or migration routes. The purpose of the SGRE Bat Protection System is to monitor the local environmental conditions in order to reduce the risk of impact on bats.

Specific environmental conditions can be monitored by means of dedicated additional sensors: temperature, light, humidity and rainfall. If conditions for the existence of bats are met, the Bat Protection System tool will request the wind turbines to be paused. As soon as one of the conditions is no longer met, the affected wind turbine will return to its initial status prior to receiving the pause order from the tool, depending on the configured hysteresis values.

The tool does not require all the sensors associated with the conditions to be installed and, depending on each site, the sensors needed will be configured. If there is no sensor for a specific environmental variable, condition is configured as fulfilled.

Additionally, Bat Protection System can be configured to be triggered depending on calendar (day/time), wind speed range or wind direction.

Bird Detection System

The Bird Detection System is a stand-alone system that monitors the wind farm's surrounding air space and detects flying birds in real time. At the same time, it is capable of handling real-time actions related to bird detection, such as warning and deterring birds at risk of colliding with the wind turbines or automatic shutdown of the selected wind turbines.

Modular configurations

To support the transportation of main nacelle components in markets with special logistic requirements, the Siemens Gamesa 4.X platform is designed with a wide range of modular transportation alternatives to fit optimally with the project's height and/or total weigh limitations for components, providing the best possible approach for transportation by sea, road or railway.

Fire protection system (Standard)

The SG 5.0-145 is equipped by default with different sensors directly or indirectly involved in fire detection and prevention. These sensors connected to the turbine controller will trip the medium voltage switchgear, disconnecting the wind turbine from the grid. These switches will detect arcs in the transformer compartment, faults to earth which trip the neutral protection relay, smoke in the nacelle room and in the tower base, transformer fuses melt or high temperature in the transformer windings.

In addition, arc detectors are placed in the transformer room and passive fire protection blankets (wool rock isolation covered by aluminum fiber) are installed.

Optional Active Fire Extinguishing System

This system combined with the passive protection system minimizes the threat of fire and prevents its propagation. The Active Fire Extinguishing System also works when the wind turbine is stopped or even when the wind farm has no energy supply.

The detection is carried out by means of high-efficiency aspirating detectors (ASD) which constantly absorb air samples from inside the nacelle and the electrical cabinets and transport them through a piping network until the analysing chambers, in order to take the reading of existing smoke concentration in the air. Depending on the different readings and according to the pre-established comparison levels, the corresponding alarm signals will be activated.

Fire detection is done at a very early stage so that preventive measures can be taken on time to abort it.

The alarm communications are sent through electrical signals to the control system of the wind turbine (PLC) and through optical-acoustic devices.

The extinguishing system discharges a fire protection agent applied as a gas through a nozzle to the electrical cabinets. This extinguishing agent offers a unique combination of safety, low environmental impact and high extinguishing performance.

Automatic lubrication systems

An optional Automatic Lubrication System may be provided for several turbine components such as the blade bearings, the low speed shaft bearings, the generator bearings and the yaw system.

The lubrication systems consist of an electrically driven pump, which supplies grease to the turbine components to increase the time between greasing maintenance operations.

2.2. CARACTERÍSTICAS DE VIALES Y PLATAFORMAS APARA AEROGENERADORES SG 6.6 170

(Utilizadas como base para la obra civil del proyecto.)

SIEMENS Gamesa RENEWABLE ENERGY

Site Roads and Hardstands

SG 6.6-170

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Updates made since the previous revision
Update of hardstand gradients in section 3.2.4. Change of T145&T150 main crane boom assembly area length. Actualization of minimum supported load values with mounted crane movement in Section 3.1.3. Added comment from BoP in reference to the possibility of adapting to local standard sections 3.1.2., 3.1.8.& 5.2. Added comment from BoP in reference the obligatority of maintaining text in corresponding sections. Construction comment added in section 1. regarding the obligatority of respecting minimum values. Logistic comment in section 3.1.4., 3.1.5., 3.1.6. & 3.1.7 in reference to the need to validate inputs by local team. Update of hardstands layouts legends in section 3.2.5. Inclusion of comments about the minimum features required for the blade storage area in section 3.2.5. Definition as SGRE Standard Strategy 4 in section 1. Addition of section 5.4. Additional documentation

Applicable Siemens Gamesa 5.X Product Variants
SG 5.X-170

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Table of contents

1. Aim and scope 3
2. Definitions and acronyms 5
3. Description 6
4. Additional documentation 30
5. Annexes 31

1. Aim and scope

The aim of this specification is to describe the requirements of the roads and hardstands required for a safe component transportation and assembly of the wind turbines. These requirements must be revised and adapted by the SGRE local teams, always respecting the limitations set for each parameter. Additionally, it includes the minimum deliverables that will be needed from SGRE to start with the transportation and erection works. The scope includes all W.F. with the following WTG models and erection strategies:

Tower	No. of tubular steel section	Power	Blade
T100	4	6.6	SG170
T110.5	6	6.6	
T115	5	6.6	
T135	6	6.6	
T145	6	6.6	
T150	7	6.6	
T155	7	6.6	
T165	8	6.6	
T165MB	2	6.6	

Table 1. WTG models

Tower	STG3	STG4 (SGRE Standard)
T100	✔	✔
T110.5	✔	✔
T115	✔	✔
T135	✔	✔
T145	✔	✔
T150	✔	✔
T155	✔	✔
T165	✔	✔
T165MB	✔	✔

Table 2. SGRE strategies

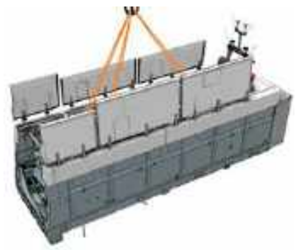
Strategy	Nacelle	DT	Hub	Blade
Strategy 3	**Modular** 	**DT/Hub** 		**Blade To Blade (SBI)** 
SGRE Standard Strategy 4	**Modular** 	**DT** 	**Hub** 	**BladeTo Blade (SBI)** 

Table 3. Components of each strategy

This document should be used either adding the project specific requirement in external notes or as a base for a complete project specific requirement. In both cases the parameters/ texts set as minimum must be respected.

Note:

This specification sets a guide to be followed for the design and construction of a wind farm civil engineering project. The project undertaken in accordance with this specification must be reviewed and approved by SGRE prior to execution. However, the civil designer is solely responsible for making sure that the design complies with this specification, the contract requirements and local norms and standards.

2. Definitions and acronyms

Acronyms	Definition
SGRE	Siemens Gamesa Renewable Energy
Main crane	Capable of lifting each component to its position in the wind turbine.
Pre-installation crane	Used for installing elements at the lower part of the tower.
Tailing crane	Supports the main and pre-installation crane for mounting and unloading components.
Mobile crane	Telescopic mobile crane
	Lattice boom mobile crane
NTC	Narrow-Track Crawler Crane
WTC	Wide-Track Crawler Crane
Intermediate hardstand	The work area for wind turbine assembly is parallel and close to the internal roads of the wind farm.
End-of-road hardstand	Work area for wind turbine assembly at the end of an internal wind farm road.
Wind farm access roads	These roads do not pass by asphalt roads and they are used to transport components and disassembled cranes.
Wind farm internal roads	Roads that pass between wind turbines for the transportation of components/crane and if required with the capacity for moving cranes.
SP	Standard Proctor
MP	Modified Proctor
WTG	Wind Turbine Generator

Table 4. Acronyms and definitions

3. Description

3.1. Roads

3.1.1. Reference legislation

The legislation of the corresponding country on the design of civil engineering must be applied. If there is no such legislation, the legislation given as a reference in section 5. Annexes should be followed as a guide.

3.1.2. Design of the windfarm internal roads

In case there is no legislation for the road design the dimensioning of the road pavement should be based on the AASHTO method for roads with a low volume of traffic (Part 2, Chapter 4). This methodology is based on an empirical formula that relates the characteristics of the pavement layers with their performance, in order to determine whether the road pavement section will be capable of bearing the traffic loads to which it will be applied.

The design of the road and the geotechnical report will be provided to Siemens Gamesa together with the quality control of the roads during the handover of the civil works and before starting with the transportation and the erection process.

This text (3.1.2.) must be kept intact in the project specific requirements and can only be adapted to the local standard, if any, for these specific low volume roads***.***

Road composition and structure

Wind farm access roads must support a **minimum load** of 12t per axle corresponding to the transportation of wind turbine elements and crane elements.

Internal wind farm roads must support a **minimum load** of:

- Without mounted crane movement:
    - 1.4 kg per cm² in the case of crawler cranes (NTC and WTC).
    - 22.5t per axle in the case of mobile cranes.
- With mounted crane movement:
    - 2.45 kg per cm² in the case of crawler cranes (NTC and WTC).
    - 22.5t per axle in the case of lattice boom mobile cranes.
    - 24.5t per axle in the case of telescopic mobile cranes.
    - 14.7t per axle in the case of pre-installation telescopic mobile cranes.

The dimensions of the roadbed must be in accordance with the number of WTGs at the wind farm, allowing for the number of transport vehicles per WTG.

Tests must be carried out on the material used for the subgrade and for the roadbed, in order to control the compaction of the different layers and ensure that the civil works are correctly executed. The quality control and the requirements for the civil works design is defined according to the ***5.2 Quality tests and requirements for civil works plan projects.***

Suitable compaction means must be used to find a subgrade of enough elasticity modulus value. The elasticity module will be measured from the compressibility module of the second cycle of the loading plate test as per DIN 18134 (or in its absence, NLT-357), the acceptance criteria will be indicated in the road section design.

The dry density required after compaction for the different types of materials forming the roadbed is 98% of that obtained in the Modified Proctor (MP) test or above.

Fill material will be compacted in layers to a maximum thickness of 30 cm to ensure the effectiveness of the machinery along the entire section.

Where expansive material (expansive clay, etc.) or loose soil conditions are indicated in the geotechnical report, the use of geosynthetics is strongly recommended (at least with the soil reinforcement and separation functions).

The elasticity module of the finished roadbed must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), and the result must never be less than Ev2=80 MPa (*). Likewise, the relation between the first and second load cycle must be less than 3.

(*) In countries where the load plate is not usually used, use the following relationship to obtain the acceptance criteria for the roadbed built:

$$E = \frac{\pi \cdot (1 - v^2)}{3} \cdot Ev_2$$

- E: elasticity module
- v: Poisson's ratio
- Ev2: second plate loading test cycle compressibility module

Additionally, the dry density compaction level for the different types of materials forming the roadbed will be 98% of the MP test result or above.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

3.1.3. Road width

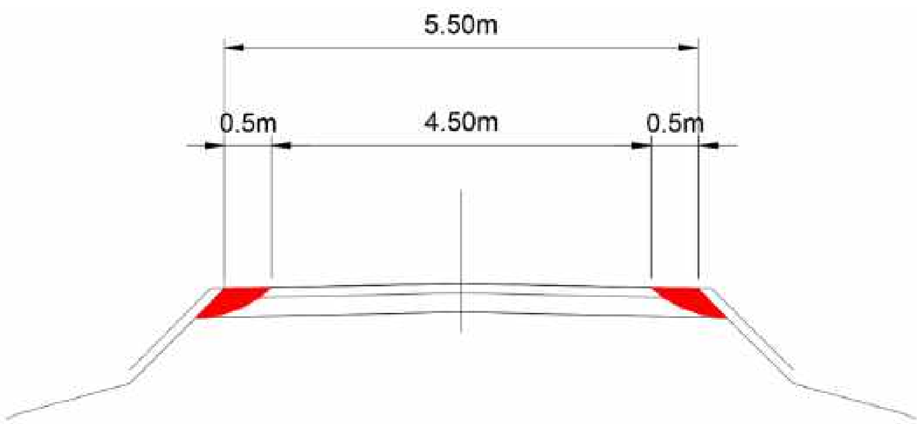
The road width will vary for curves according to the following section 3.1.5. Curve widening – General.

<table>
<tr><th colspan="2">Minimum road width</th></tr>
<tr><td>A. Wind farm access road transportation of components</td><td>As a minimum and usable 4.5m*(**) + 2 x 0.50m of obstacles in straight sections.
As a minimum and usable 5.0m*(**) + 2 x 0.50m free of obstacles in curves.
As a minimum and usable 5.5m* + 2 x 0.50m free of obstacles in case of reverse driving.</td></tr>
<tr><td rowspan="3">B. Internal wind farm road with crane movement</td><td>Pneumatic Crane
As a minimum and usable 4.5m + 2 x 0.75m free of obstacles</td></tr>
<tr><td>WTC
• Usable 12 to 14m*
• 4m + 3m parallel tread (making 12 to 14 m)</td></tr>
<tr><td>NTC
As a minimum and usable 7m</td></tr>
<tr><td>C. Access road to the wind farm Transportation of components and Internal roads of the wind farm without crane movement. (Wind Farms in the United States)</td><td>As a minimum and usable 5m + 2 x 0.8m free of obstacles</td></tr>
<tr><td colspan="2">Note:
Usable m (meters) - Space capable of bearing the loads to which the road will be submitted without the risk of caving-in, sliding or sinking. Furthermore, the last 50cm prior to the curbs on these roads (not included in the usable meters) are not valid for withstanding weights, due to the danger of horizontal creep of the ground. Thus, the carrier transporting the nacelle and heavy haulers in general must never go beyond these limits under any circumstances whatsoever.
This table marks the minimum requirement for the road width as general.
There may be more limitations on the use of road width project specific. On the one hand, the safety distances or calculation limitations on the edge of high embankments and on the other hand, the possibility of splitting the road into two parts for crawling with WTC cranes. These should be mentioned by the wind farm designer.

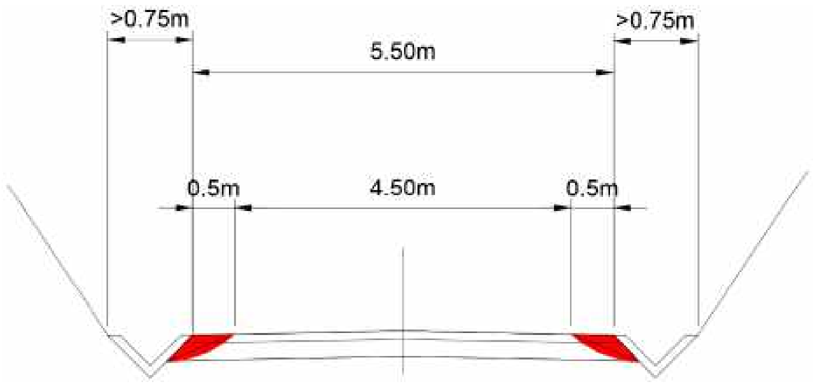
*Width based on crane model
(**) The minimum useful width to assure a safe transportation of the wind turbine components must be 4.5m on straight and 5.0m in curves. In the case of not being able to meet the minimum width depending on the characteristics of the site and the availability of transport equipment for cost optimization, environmental issues, or others, this should be agreed between the SGRE´s customer, the own SGRE Local and the transport company awarded the project. Regarding the usable width in curves, a new turning radius study should be carried out by SGRE Local.</td></tr>
</table>

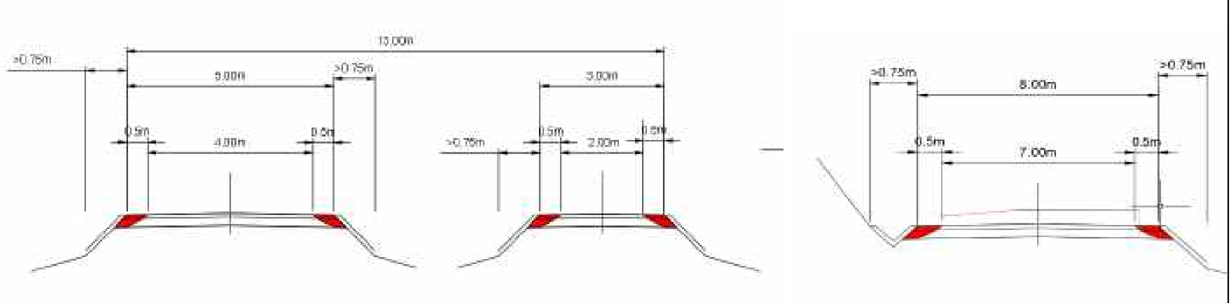
Table 5. Minimum road width in access and internal roads

A. Wind farm access road Transportation of components



B. Internal wind farm road with crane movement





C. Access road to the wind farm. Transportation of components and Internal wind farm road without circulation of cranes (e.g wind farms in the United States)

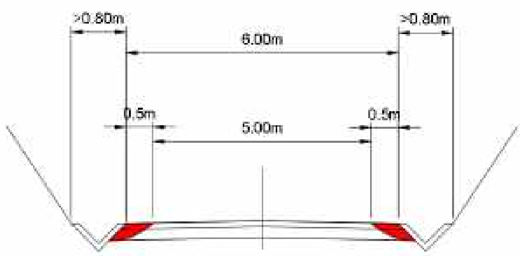


Figure 1. Minimum road width in access and internal roads

For curves with an interior cleared profile, the inside curb of the curve must be pipelined or have a maximum depth of 10 cm.

The slope of cutting on internal roads must be limited in accordance with the wind farm's geotechnical survey and determined by the crane being used for assembly. The most restrictive case is movement of NTC without dismounting.

This section (3.1.3) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

3.1.4. Curve widening – General

The smaller the curve radius of the alignment curve, the greater the road width must be (difference between outside and inside radius) at the curve.

Blade transportation is considered a limiting element in the calculation of curve widening.

The following example table is completed for each model with these widths:

- A: Road width
- SAE: Exterior widening
- SAI: Interior widening
- De: Entrance widening development
- Ds: Exit widening development

RADIUS - ANGLES					
	90º				
	A	**SAe**	**SAi**	**De**	**Ds**
R35	7	24	11	1	20
R40	…	…	…	…	…
R45	…	…	…	…	…

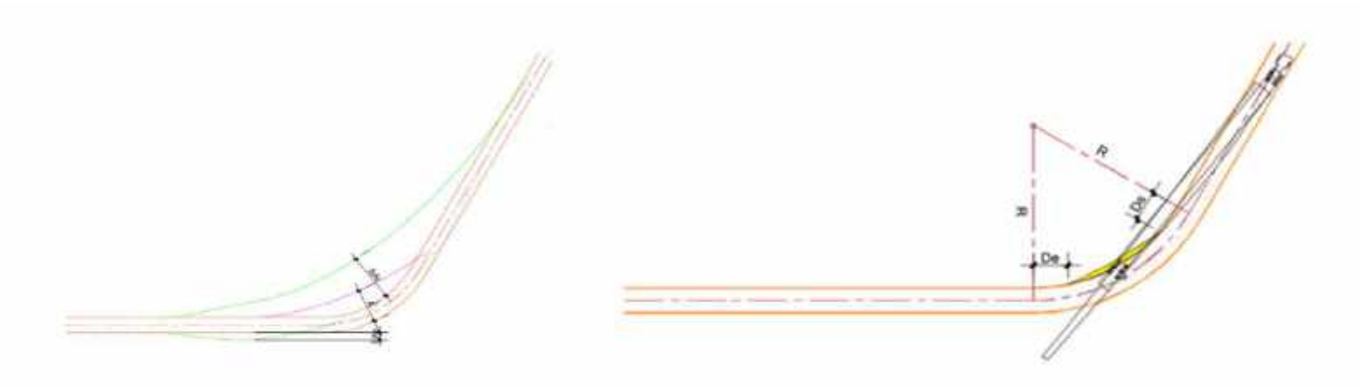


Figure 2. Curve widening

The conclusions of the study will be reflected in a table where:

- A: Road width
- SAi: Is the maximum interior sweep of the vehicle or its cargo
- SAe: Is the maximum exterior sweep of the vehicle or its cargo
- R35: Represents the radius curve at the centre of the road
- 60º: Represents the angle formed by two straight sections of road joined by a curve of a given radius
- De: Distance from the first point of tangency to the beginning of the widening
- Ds: Distance from the end of the widening to the second point of tangency

The transport vehicles used to transport various components of the turbine up to the site should be equipped with self-steering rear axles in those countries and projects where this type of equipment is feasible.

A study for guidance was made taking in to account an estimate vehicle (General vehicle). Each region will provide a study of curve radius with its most restrictive vehicles. As an example in the ***5.1 Transport requirements***, the general results analysis for turbine model is included. This example should not be used as the values are not updated.

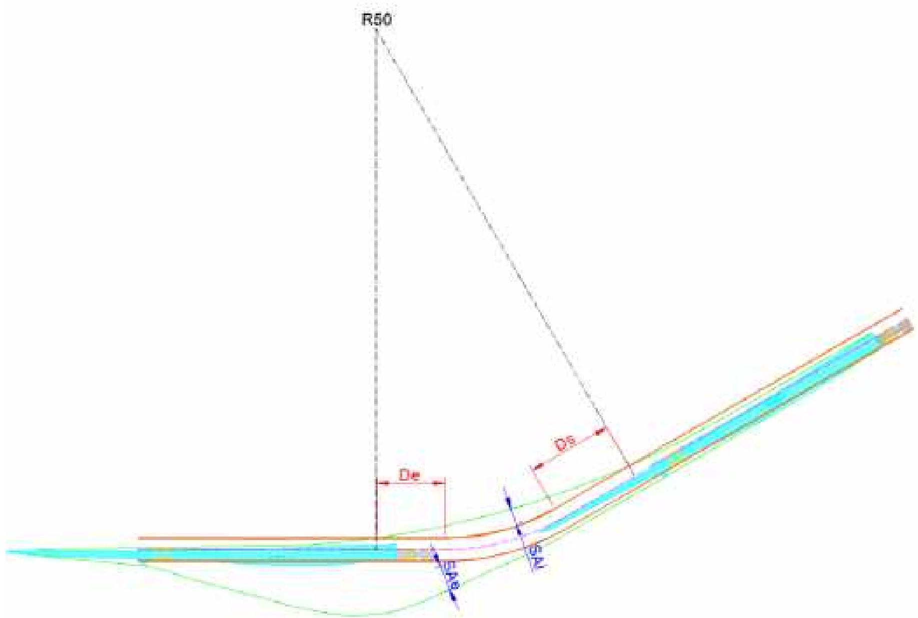
SGRE local team shall confirm/validate or update the data included in the generic specification where estimated theoretical vehicles have been considered against planned vehicles to be contacted for each specific project.

Besides, per each specific project, inner and outer widening for each curve along the route should be studied per transport simulation.

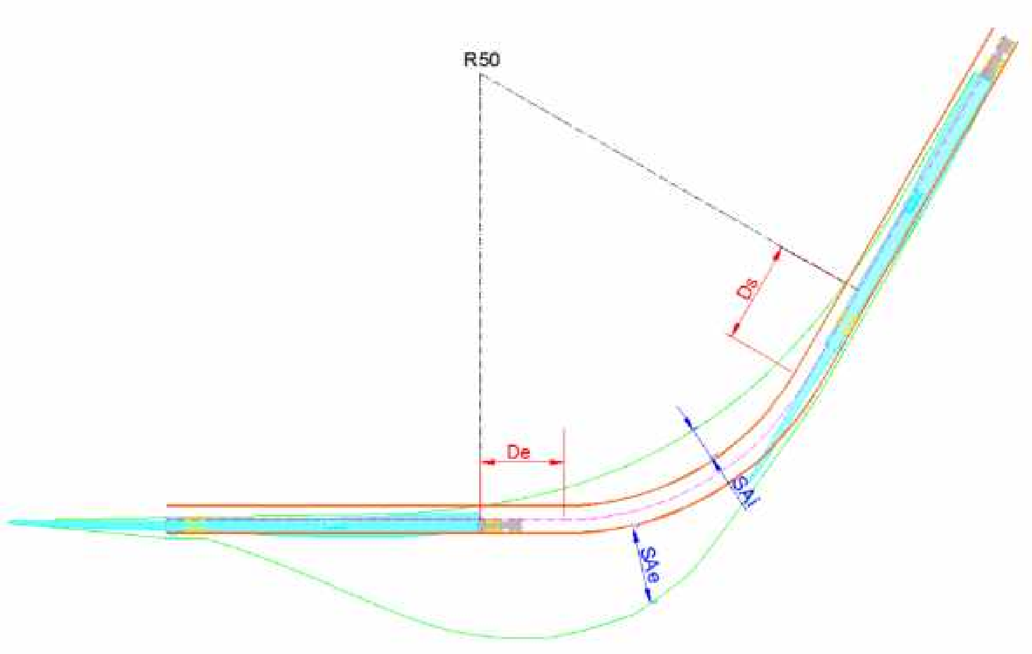
SGRE has available curve widening table for each region with a generic transport, which should be validated project by project.

Below are three examples to follow for the definition of curve widening. Final drawings are to be submitted by the region.

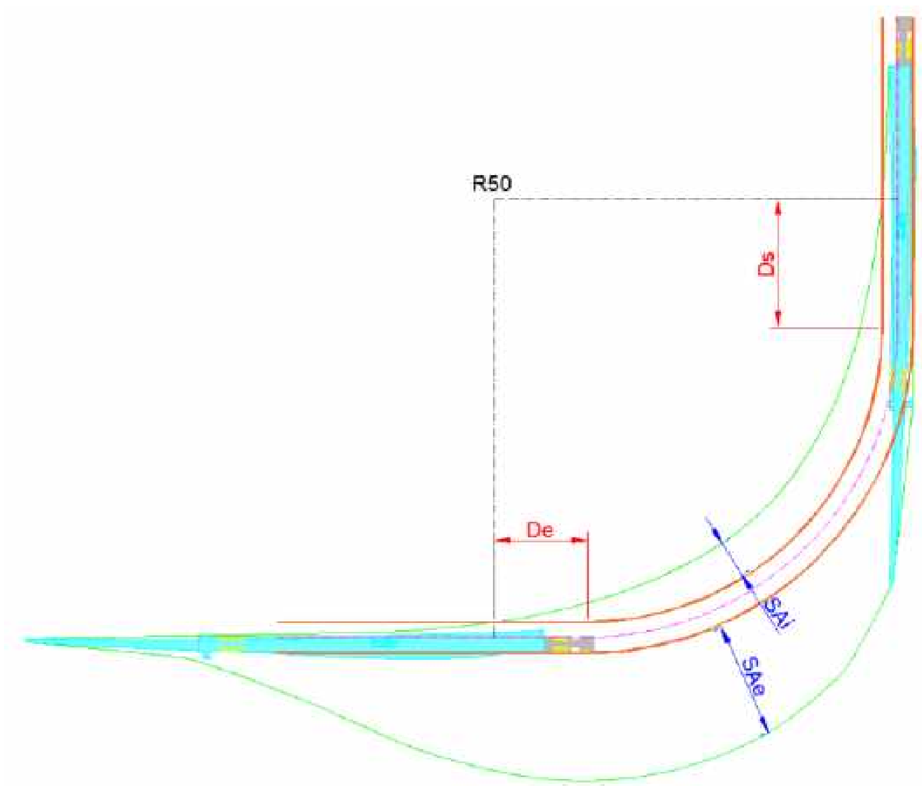
- **<u>SG 170 Alineación a 30º y Radio 50m:</u>**



- **SG 170 Alineación a 60º y Radio 50m:**



- **SG 170 Alineación a 90º y Radio 50m:**



This section (3.1.4) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

3.1.5. Gradients and grade changes

SGRE local team shall confirm/validate or update the data included in this document where estimated theoretical vehicles have been considered against planned vehicles to be contacted for each specific project.

The below values are to be confirmed by the region project by project.

<table>
<tr><th rowspan="3"></th><th colspan="4">Longitudinal Gradients (%)</th><th colspan="2">Transversal Gradients (%)</th></tr>
<tr><th colspan="2">Maximum</th><th colspan="2">Minimums</th><th>Maximum</th><th>Minimum</th></tr>
<tr><th>Straight section</th><th>Curved section</th><th>Straight section</th><th>Curved section</th><th colspan="2">Straight/ curved section</th></tr>
<tr><td>Wind farm access road and internal wind farm road</td><td>>10 and ≤13 without concreting if gradient < 200 m. (1)

>10 and ≤13 improved concreting or paving if gradient > 200 m.(1)

>13 and ≤15 improved concreting or paving + 6x6 tractor unit

>15 need for towing study</td><td>Up to 7 without concreting (1)

>7 and ≤10 improved concreting or paving (1)

>10 need for towing study</td><td>0.50</td><td>0.50</td><td>2</td><td>0.20</td></tr>
<tr><td>Access and internal roads reverse driving</td><td>≤ 3 up to a max. of 1000 m without concreting.

>3 and ≤5 max. 1000m improved concreting or paving</td><td><2 up to max. 500 m without concreting.

≥2 and ≤3 max. 500 m improved concreting or paving</td><td>0.50</td><td>0.50</td><td>2</td><td>0.20</td></tr>
<tr><td colspan="7">(1) SGRE standard values are ≤13 % for longitudinal gradients and <10 % for curved sections.
(2) Improved paving: Roadbed with friction coefficient of at least 0.35</td></tr>
</table>

Table 6. Gradients and grade changes

For gradients near 10% without concreting, 6 x 4 tractor units or four-wheel drive truck will be required.

In the specified cases in which road paving must be improved, the solution to be used and the envisaged friction coefficient must be submitted so that transport can be executed.

In the specified cases in which road paving must be improved, the technical characteristics of the solution to be used must be submitted, as well as the friction coefficient for the roadway layer envisaged for said solution, thereby ensuring that all components are transported correctly.

If the longitudinal gradient is >13% and ≤15%, improved concreting or paving will be required, and a 6 x 6 tractor unit used. This means that the slope will also have to be reviewed since it is not within SGRE standards.

In the extreme case that a longitudinal gradient in a straight section is >15% and/or is >10% in a curved section, a towing study must be conducted in addition to improving the road paving along the affected section. This study must be conducted by the logistics company in charge of supplying the wind farm with the wind turbine components.

Regarding to guarantee the proper transitions between gradient changes, the minimum straight-line total length of the convoy must be kept in mind. According to the complexity of the wind farm project, these points must be analyzed and discussed to find the proper solution.

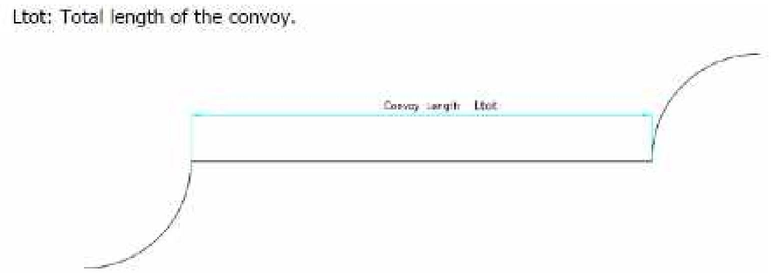


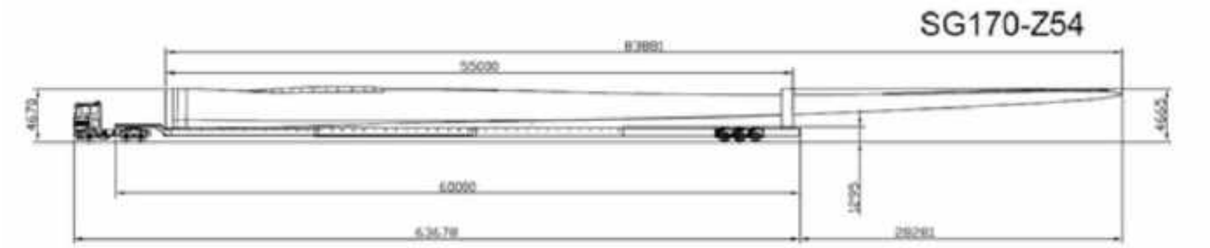
Figure 3. Transitions between gradient changes

For the calculation of the more restrictive KV that appears in this document, estimated generic vehicles have been considered. This does not mean that there are not others that improve or even worsen the KV figure. It is advisable to carry out a specific study in each region of the SGRE, with the vehicles planned to be used in local projects.

The KV value considered in the wind farm design for this WTG model shall be, **as a minimum:**

Transport	**Z54**	**Dolly**
Kv Value	**690**	**610**

With the information we have now, **the most restrictive transport would be the SG170 blade on Z54 transport.** Bearing in mind that all the axles of the platform would be in contact with the ground. Considering that all the axles of the platform would be in contact with the ground and a rear overhang of 15,64m. Which of course will be different considering the restrictions of each country. The overhang may differ according to the restrictions of each country, which should be considered.



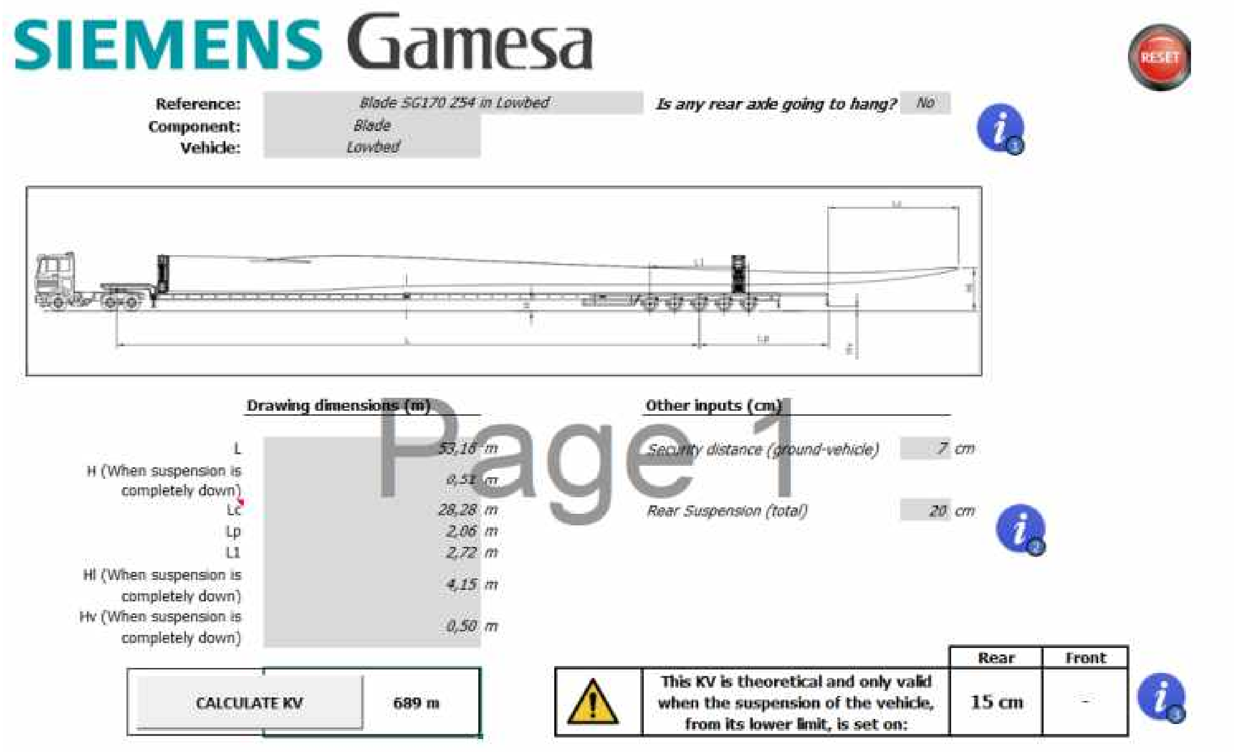


Figure 4. The most restrictive transport and its respective KV

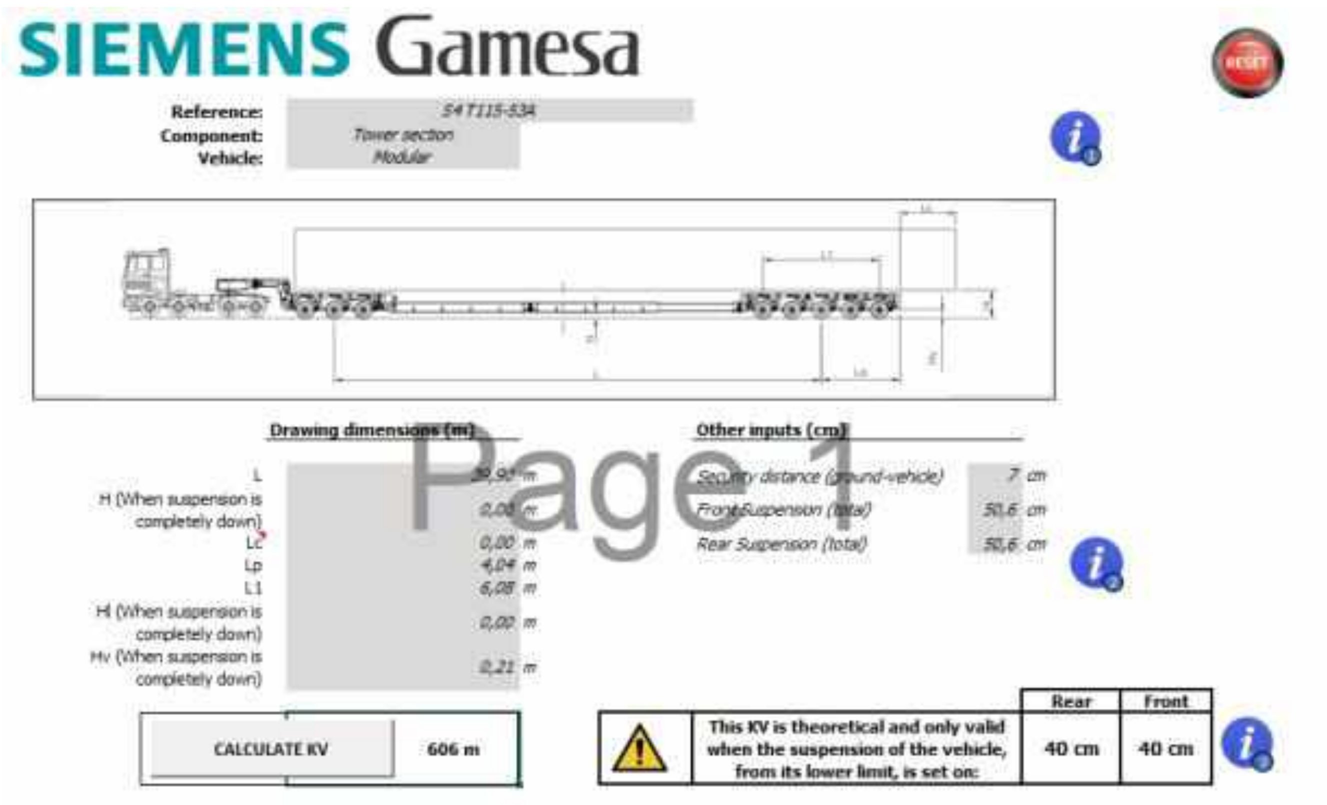


Figure 5. The most restrictive transport in dolly and its respective KV

The value above is for reference only, project value to be confirmed by the region. Depending on the complexity of the terrain, the KV value that minimizes LCoE (levelized cost of energy) might be higher (flat wind farm) or lower (mountainous wind farm). Prior to signing the contract, a specific study shall be done in order to define the proper KV for the wind farm, considering development constraints in force and locally available transports in order to adapt logistics means accordingly.

The specific study could include nonstandard solutions and extra resources for each solution.

The roads must be smooth, removing, as far as possible, any protrusions such as stones, rocks, etc., which could damage the nacelle hardstand or the tower sections and hinder transportation.

This section (3.1.5) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

3.1.6. Passing areas and turning points

Passing areas will be created at intervals of approximately 5 km, attempting to take advantage of the areas where there are less actions to be performed if possible and they must have an extra width of 5 m with a minimum length equal to the total length of the convoy (Ltot) with a greater length. It is important to consider the entry and exit areas to facility access to the area. The waiting areas must be clear of any obstacle, levelled, compacted and drained. QHSE will determine the number of rest areas that must be created.

The turning points must be defined according with the maximum allowed reverse manoeuvre as described at the item ***3.1.5 Gradients and grade changes.***

Where dead end roads are constructed or where loaded transports must turn around prior to delivery to the Installation Area, turning Areas are required to avoid long reverse driving. For each wind farm project, these points must be analysed to find the proper solution.

(Note) Truck length* - The turning area will be different considering two situations: Loaded truck and empty truck. The additional area must be considered around the turning point - cleared of obstacles and levelled to allow oversail/ overhang during transportation. The turning point could be adapted regarding the orography and/or complexity of the windfarm terrain, the new geometry must be approved by SGRE in order to comply with the transport requirements.

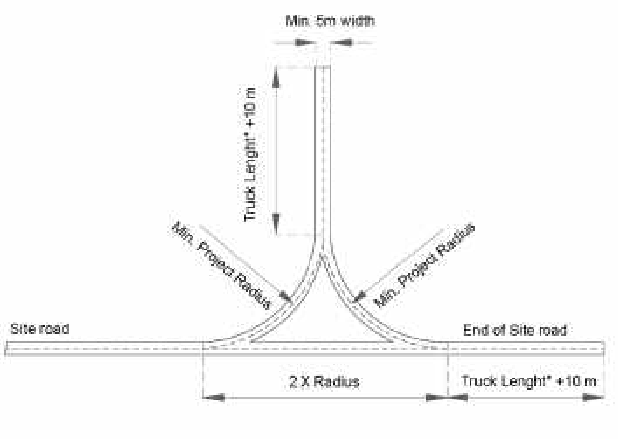


Figure 5. Turning point geometry suggestion

SGRE local team shall confirm/validate or update the data included in this document where estimated theoretical vehicles have been considered against planned vehicles to be contacted for each specific project.

These can be adjusted on project specific.

This section (3.1.6) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

3.1.7. Drainage

The surface drainage system must be of a size to collect any rainwater from the roadway layer as well as any water collected from small flows of runoff water intercepted by the road or even, where applicable, to provide continuity for any larger natural watercourses also intercepted. The calculation will be considered for a minimum return period of 25 years for transverse drainage and 10 years for longitudinal drainage works.

This text (3.1.7.) must be kept intact in the project specific requirements and can only be adapted to the local standard, if any, for these specific low volume roads.

3.2. Hardstands

The hardstands will include a crane work area and areas defined as storage areas. The main components will be stored on the storage area, and they will be hoisted by the cranes from the hardstand – crane work area, as a standard concept. Regarding the high-power and communications networks avoid placing them across the hardstand. If this cannot be avoided, then the network must be pipelined, and the pipes covered with concrete.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

3.2.1. Hardstand design

The design of the hardstand section must be done based on the geotechnical report and the load transferred by the crane support legs, also it must be considered the use of crane mats if any, under the crane support.

The structural verifications that must be performed and the criteria to be used is as follows:

- For the bearing capacity analysis, Meyerhof and Hanna (1978) methodology will be used.
- The safety factor for the verification of the bearing capacity will be 2, for both long term and short term.
- For the analytical calculation of the settlements, the Steinbrenner methodology will be used.
- The maximum differential settlement under the crane support leg will be 40 mm.

When it comes to unfavourable geotechnical conditions, in addition to the verifications carried out with analytical methodologies, described above, it will be necessary to develop a finite element model (FEM) to compare and contrast the results obtained with analytical methodologies.

The design of the hardstand and the geotechnical report will be provided to Siemens Gamesa together with the quality control of the hardstand, during the handover of the civil works and before starting with the erection process.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

3.2.2. Bearing capacity

	Crane work area	Component storage area	Boom assembly area
SGRE standard	2.5	2	2
Without crane mats	3 (T100) 3 (T110.5) 3 (T115m) 4 (T135m) 5 (T145m) 5 (T150m) 5 (T155m) 5 (T165m)	2	2

Table 7. Load -bearing capacity (kg/cm2)

The composition of the crane work area must have a good subgrade, Ev2=60MPa or above. Transmitted loads must be 2.5kg/cm2 (approx. 0.2MPa). A surface of 30 m² must be laid, 6 crane mats (5 m x 1 m) per crane leg or crane chain.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

If opting not to use crane mats, the necessary bearing capacity will be 3 kg/cm² for T100m, T110.5m and T115m, 4 kg/cm² for T135m and 5 kg/cm² for T145m, T150m, T155m and T165m tower models. The possible supply of crane mats is not included in the scope of SGRE, whereby if opting to use crane mats, the cost thereof shall be incurred by the Contracting Party.

3.2.3. Hardstand composition and structure

In the hardstand, the upper level of the subgrade must be above the highest foreseeable level of the water table. Where expansive material (expansive clay, etc.) or loose soil conditions are indicated in the geotechnical report, the use of geosynthetics is strongly recommended (at least with the soil reinforcement and separation functions).

The fill material will be compacted on the hardstands and in the storage areas in layers to a maximum thickness of 30 cm to ensure the effectiveness of the machinery along the entire section. The compaction level will be such that the dry density after compaction is 95% MP or higher. The elasticity module of the subgrade must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), the acceptance criteria will be indicated in the hardstands section design.

Regarding the finished hardstand, the compaction level will be such that the dry density after compaction is 98% MP or higher. The elasticity module of the finished hardstand surface must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), and the result must never be less than Ev2>80 MPa.

In case there is a doubt about the hardstand capacity, it will be necessary to execute at least one borehole, in the centre of the crane area, with core recovery and a depth of 8m. During the execution of the borehole, the following works should be conducted:

- SPT: from the surface where a test must be performed every meter.
- Extracting non-disturbed samples, plus laboratory test (triaxial tests or direct shear tests).
- Determining the ground water level depth, if encountered.
- Collect sampling for laboratory characterization of all the encountered materials.

The storage areas that are at the same level and position of the crane work area (for towers and nacelle), the requirements for the subgrade and finished layer are the same as above-mentioned. For the blade storage areas, the compaction level of the subgrade will be such that the dry density after compaction is 95% MP or higher. In case of need of granular layer, the compaction level will be such that the dry density after compaction is 98% MP or higher.

In case the subgrade of the storage areas is good enough to withstand the loads, no layer of granular material will be needed, but this must be justified accordingly in the design.

Tests must be carried out on the material used for the subgrade and for the roadbed, in order to control the compaction of the different layers and ensure that the civil works are correctly executed. The quality control and the requirements for the civil works design is defined according to the ***5.2 Quality tests and requirements for civil works plan projects.***

Before the arrival of the transport vehicles and crane, the hardstand must be accepted by SGRE for the works to commence.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

3.2.4. Hardstand gradients

Crane Type	Hardstand gradients (%)			
	Crane work area		Component storage area	
	Maximum	Minimum	Maximum	Minimum
NTC or Mobile cranes	3	0.2	2	0.2
WTC	0.5			

Table 8. Hardstand gradients

The minimum slope in the crane work area as well as the storage area is 0.2%, for the drainage of surface water; concave areas that may result in the formation of pools and the consequential drift of material under heavy loads cannot be accepted. Furthermore, take care that the hardstand or storage area surface must not drain off onto its access road.

3.2.5. Hardstand dimensions

Hardstand layout considers standard SGRE assembly strategy 4.

Foundation diameter subject to change. In case of using special foundation solution (uplifted, braced foundation, etc.), the hardstand dimension must be evaluated and approved by specific study.

(Note) – Following hardstand layouts covering tailing crane offloading and self-offloading transports

Use of clamp system doesn’t require cranes for off-loading but additional space for manoeuvring of trailers to release the tower sections is needed. The system is not available for all regions and must confirmed by SGRE before building the windfarm. Bear in mind, once chose the hardstands without to consult or to require a confirmation from SGRE, the decision is responsibility of the civil designer. The different concept reflects an impact in hardstand layout, assembly phase and costs. Unusual situations must be evaluated and approved project specific.

Position of blade fingers is depending on location of transport equipment (TEQ) on blade -> Use of TEQ concept and/or positioning on blade might be different per region. Final location of blade fingers must be evaluated and approved project specific.

Area	Description
q1	Hardstand for main crane
q2	Hardstand for assistant crane
q3	Storage area for containers and miscellaneous items
q4	Blade storage area (including the blade fingers position)
q5	Storage area for components
q6	Hardstand for boom assembly
q7	Free obstacles area for rotation superlift ballast or suspended ballast of main crane

Table 9. Installation area codes and description

HARDSTAND LEGEND
- Site Road
- q1 Hardstand for Main Crane
- q2 Hardstand for Assist Crane
- q3 Storage/Assembly Area
- q4 Trestle area for blades
- q5 Storage area for components
- q6 Hardstand for Boom Assembly
- q7 Hardstand for Superlift ballast
- Area prepared as Hardstands q1 and q2
- Cleared area of any obstacles and prepared as a working area
- Foundation area, leveled with q1 and Site Road

The hardstand drawings can be found in annexes, section *5.5 hardstand dimensions*.

In all hardstands, 2 additional areas of 19 m x 12 m and 16 m x 12 m will be required for storing the containers and miscellaneous items. These areas must be close to the hardstand. They can be positioned alongside the foundation providing they remain accessible for removing material by boom truck or telescopic forklift.

The blade storage area will be formed by two different zones in q4. The first zone are two reinforced and levelled “fingers” where blades are supported. The second zone is the surrounding area of blade fingers in q4. As standard, the entire q4 area should be levelled with road and/or hard support next to it and cleared of obstacles in addition to maintain the said area as a working area (working area: area that must remain accessible to the cherry picker and workers during construction).

It may be necessary to include a third finger in case the transport tool and the blade preparation tool are not at the same point, in addition to the different options for locating the tip finger depending on the transport tool. This will be defined project by project by SGRE.

The top part of the blade fingers must be at the same level as the surrounding hardstand.

If the blade fingers area is higher or lower than the adjoining road, this must be approved by Siemens Gamesa as it will have an impact on the delivery of the blades.

It is considered that the leading edge of the blade is positioned in the side of the road. In case the edge of the blade is at the other side of the road a study would be necessary for the installation of the clamp. It is also essential to ensure that there is minimum 1m of area from the edge of the blade for the workers. This will be defined project by project by SGRE.

The dimensions of the vehicle and crane work areas as well as the storage areas inevitably determine the configurations of the equipment used for assembly. For this reason, this section also defines some of the standard or normal conditions used to define the basic prices as well as relevant exceptional cases.

The recommendable distance from the centre of the ring to the start of the useable surface of the hardstand will be 5 m. (Each specific case may be studied).

The concrete foundation pedestal and hardstand must have the same level where possible.

It can be lower with prior approval from SGRE.

If design requirements call for the foundation pedestal level to differ from the ground surface potentially the level of standard hardstand layout will differ from foundation pedestal, too. In case of a project specific evaluation together with SGRE is required (e.g adaptation of hardstand level to foundation pedestal level or change of crane set up and updated of size of the hardstand).

(Note: If opting for an elevated foundation due to design reasons, its height in relation to the hardstand should be considered as tower height.)

Intermediate hardstand adjacent to the road, but at a different level, must have a separate hardstand entrance and exit. Otherwise, it must be considered end-of-road hardstand.

For end-of-road hardstands, the foundation should be at the end of the hardstand, avoiding having the foundation at the entrance of the hardstand as much as possible.

The hardstand and road must be at the same level to be able to operate support cranes located partially on hardstand and road.

3.2.6. Requirements for tower assembly with T-flange configuration between section 1 and 2

A compacted area around the tower (on top of foundation) needs to be prepared in advance of start of 1st tower section installation. This is needed to enable tower access from all sides for installation of T-flange bolt joints with e.g., cherry picker (man basket).

The compacted area needs to have a minimum width of 10m for operation of cherry picker.

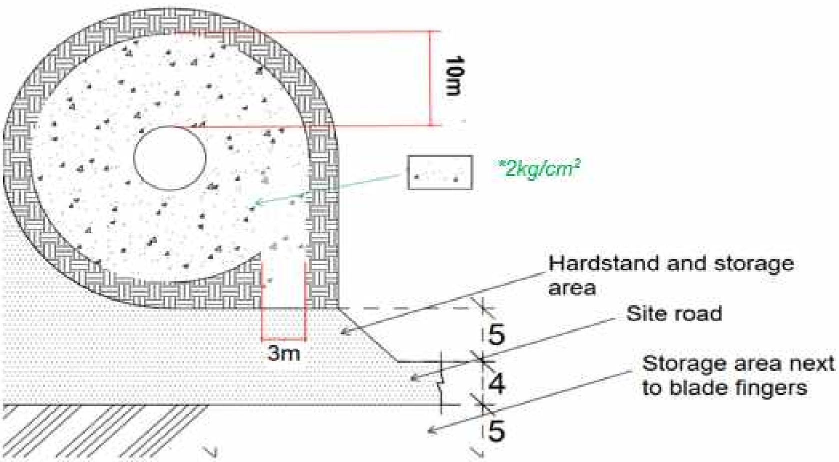


Figure 6. Example of hardstand layout and access road/ramp

Note:

If an elevated foundation is applicable a road/ramp for access to compacted must be created, too. Maximum gradient of 15% must be considered.

*The bearing capacity for the backfilling is a recommendation for complying with the CNS requirements. This number needs to also fulfil the foundation design requirements.

3.2.7. Requirements for assembly the main crane

If there are several branches far away from one another, an area must be prepared for assembling and disassembling the boom of the main crane at the beginning and end of each wind farm branch or on each hardstand depending on the crane model to be used.

The boom assembly configuration and area may vary according to the crane models to be used.

If there are very steep gradients, power lines, etc., more assembly and disassembly areas for the boom of the main crane may be needed on each hardstand.

This area must have a minimum length in a straight line equal to:

- 100m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 110.5m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 115m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 135m tower: Tower height + 15m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 145m tower: Tower height + 15m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 150m tower: Tower height + 12m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 155m tower: Tower height + 12m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 165m tower: Tower height + 12m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)

		T100m	T110.5m	T115m	T135m	T145m	T150m	T155m	T165m	T165m MB
Mobile/ Crawler cranes	Wheeler Crane	Area for assembly and disassembly on each hardstand and along site road								
	NTC									
	WTC	Assembly area at the beginning and end of the Wind Farm or each branch								
Dimensions	In a straight line	119m	130m	134m	150m	160m	162m	167m	177m	177m

	Wide	3m	3m	3m	3m	3m	3m	3m	3m	3m

There must be areas without vegetation, flat and compacted with a surface area of 10 m x 12 m + 7m x 12m / 2, every 30 m along the boom for assembly for the tailing cranes operation:

Table 10. Requirements for assembly the main crane

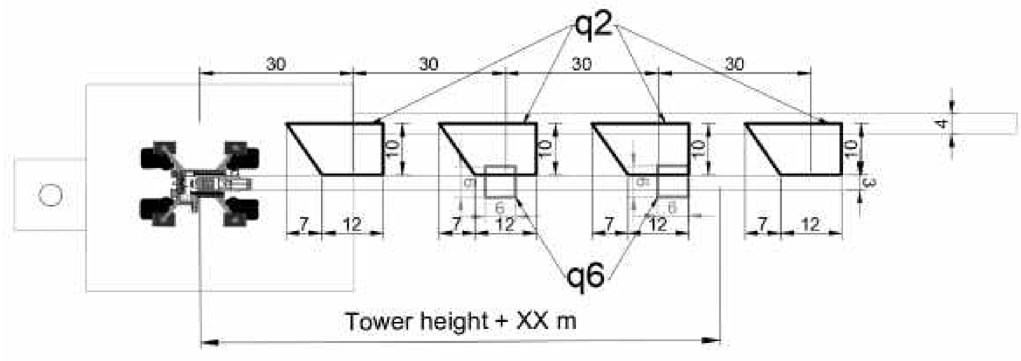
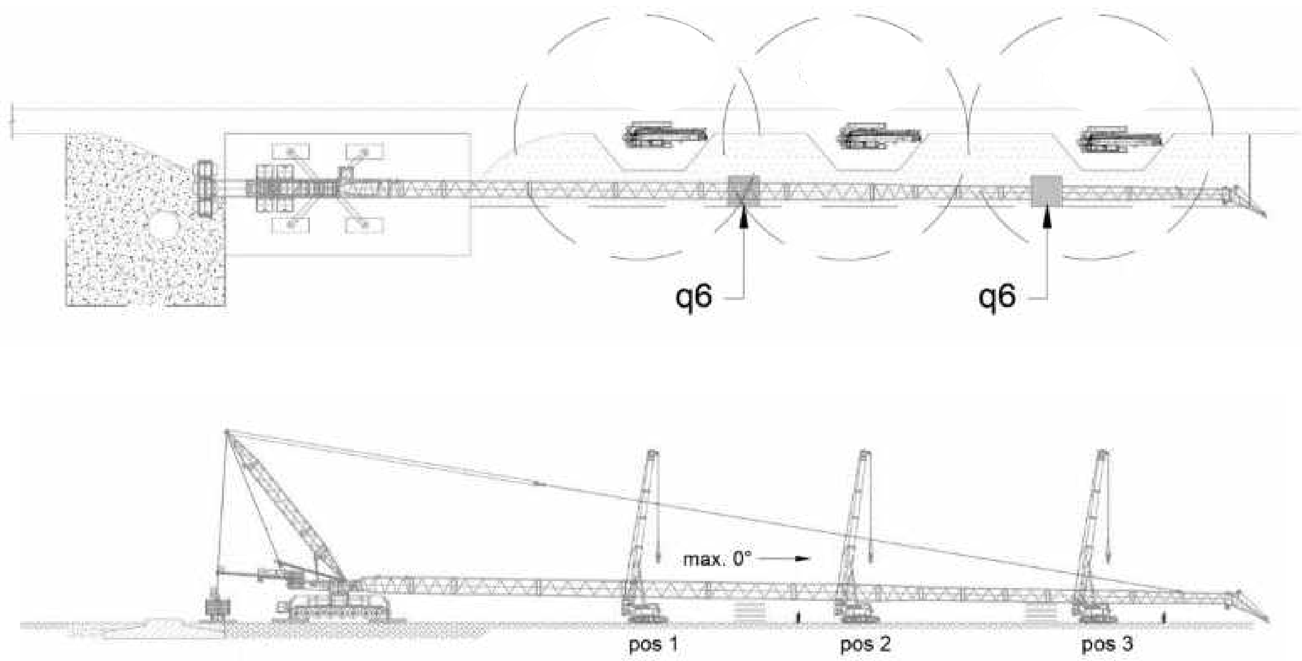


Figure 7. Distribution areas for main crane boom assembly

This area must also be as horizontal as possible, and any gradient should preferably be upward (in the direction in which the boom assembly advances). Were it downward, the boom assembly conditions would be more complex, increasing the crane means required for the assembly process. This would not be a SGRE standard and a specific study would need to be done.



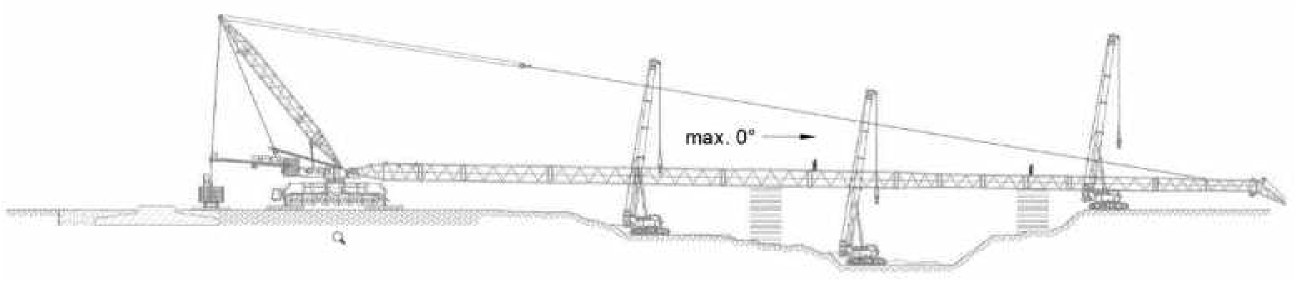


Figure 8. Boom assembly on flat and hilly terrain

Furthermore, the subgrade for assembly and disassembly of the boom, including the pre-installation crane positioning areas, must have a supporting capacity over the entire area at work level of 2 kg/cm² (approx. 0.2 MPa).

The areas for mounting and dismounting the main crane should be next to a hardstand but not overlap the hardstand area. Furthermore, they will be laid out as parallel as possible to the road reaching the hardstand, but without overlapping it, **in order to avoid invading the outgoing WF road in case of.**

3.2.8. Areas for Tag Lines

Rotor Assembly and Single blade Installation Methods (see Figure 9) require special attention for ensuring a cleared area for the safe use of tag lines.

The Employer shall ensure that the areas around the hardstand, rotor assembly area, and operating area for tag lines are prepared to allow rotor assembly and installation, or single blade installation to be completed safely. An example of the area required is shown in Figure 9. This area shall be prepared as a Working Area (free from trees, obstacles and trip hazards and prepared as to allow persons to move freely and safely). Once the Employer's civil design is finalised, the Contractor shall work with the Employer to further define and optimize these areas in order to minimise the felling and ground preparation works to be carried out by the Employer. Prior to turbine erection, the Employer and Contractor shall together survey the area to be used for tag lines and identify any safety hazards (e.g. holes, level changes, marsh etc.). The Employer and Contractor will mutually agree appropriate mitigations measures, which will be carried out by the Employer, to ensure Safe Working Access.

The drawings below are indicative only and can be furthered refined during the site visit. This is relevant for rotor assembly only.

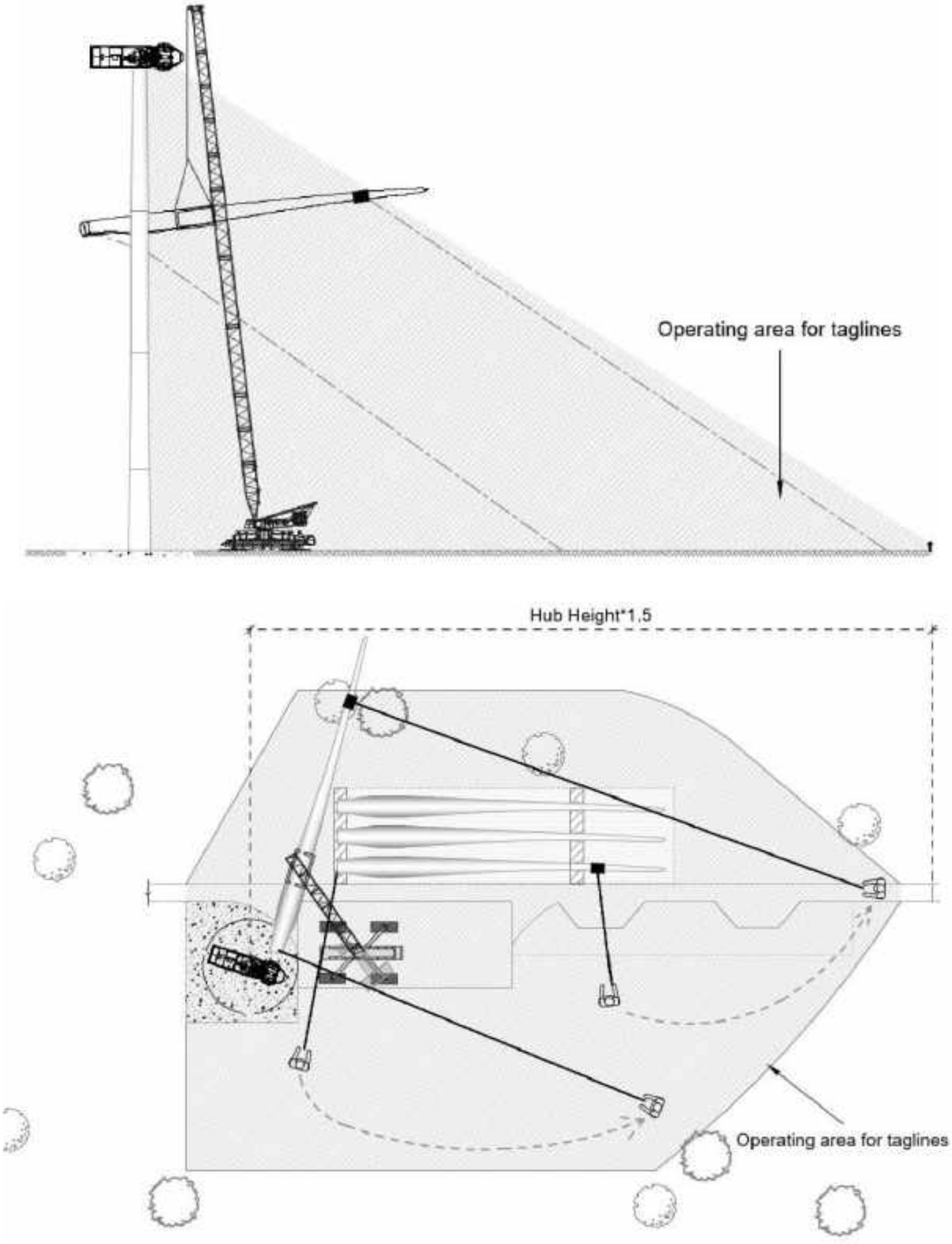


Figure 9. Indicative drawing of area requirements for the use of tag lines with single blade installation method

3.3. Minimum Requirements for temporary site compounds of wind farms

The objective of this Internal Note is to specify the minimum requirements for the temporary site hardstands including the area of the site office sheds/containers, the parking area for light vehicles and the storage area for minor materials. Normally all these areas form a single space usually called "**site compound**", which is divided into the pertinent specific areas.

The site compound is needed for the construction of a wind farm, and each area must be in good conditions for each specific purpose. Therefore, these temporary areas must be built in accordance with specific requirements.

The location of the site compound must be carefully studied, avoiding areas susceptible to suffering flood events and avoiding areas with critical natural slopes or large embankments. Preferred locations are flat areas with easy access by car or truck.

The design of this site compound must consider a slope between 1% and 3%, for a proper drainage of the rainwater in accordance with the site-specific conditions. If necessary, temporary drain ditches or culverts should also be considered to collect and divert the rainwater to the appropriate discharge points.

The construction of these temporary areas will require the following activities:

1- The area must be cleared to eliminate the topsoil, trees, stumps, weeds, etc. The topsoil can be stockpiled in small piles in the vicinity of the site compound for later use in landscape restoration if required.

2- Embankments: If relevant embankments are necessary to build the hardstand, at least the following requirements are recommended:
   - Before the construction of the embankment, the natural subgrade must be compacted until reaching 95% of the maximum dry density from the Modified Proctor test (M.P.).
   - Embankment construction must be carried out by placing fill material in max. 30cm thick layers and compacting this fill material until reaching 95% of its maximum dry density from the M.P.
   - It is recommended using a fill material with a CBR ≥4% at 95% M.P, free of organic matter, LL<50, non-collapsible, free swelling <3%.

3- Excavations: If excavation is necessary to build the hardstand, the exposed natural subgrade must be compacted until reaching 95% of the maximum dry density from M.P.

4- Pavement: The pavement details will depend on the use of each area but, as a general approach, it is recommended a granular material with a fine content ≤ 20%, a CBR≥ 40% at 98% M.P. and a maximum grain size of 32mm, when possible. This material must also be correctly compacted in max. 30cm thick layers until reaching at least 98% of the maximum dry density from M.P. ("=well compacted granular material").

Paved areas and the thickness of the pavement will depend on the site soil conditions and the associated evaluation will adequately consider the detailed geotechnical information. There may even be the case that the use of geotextiles could be necessary.

Recommended thickness of the pavement in each area is indicated below. The thicknesses must be considered as a minimum and obviously it can also be increased if the site soil conditions are not good enough.

- Temporary office area*:* it is recommended applying 10cm of well compacted granular material.
- Parking area for light vehicles*:* it is recommended applying 15cm of well compacted granular material.
- Storage area for minor materials and access road: trucks are going to use these areas. Therefore, the thickness of pavement will depend on the quality of the natural soil (subsoil):
  - Poor subsoil conditions (CBR<2% at 95% P.M.): it is recommended applying at least 30cm of well compacted granular material.
  - Fair subsoil conditions (2%<CBR<7% at 95% P.M.): it is recommended applying at least 20cm of well compacted granular material.
  - Good subsoil conditions (CBR>7% at 95% P.M.): it is recommended applying at least 15cm of well compacted granular material.
  - If rock or rocky soils are encountered, it would be enough to apply 10cm of well compacted granular material in all the areas to build a uniform, plain and sufficiently bearing hardstand.

Above recommendations must be understood as a general guide or a first approach to the structural design of the temporary hardstands.

In any case, it is always necessary to maintain adequately the pavements. If necessary, additional granular material must be placed and correctly compacted during the use of these temporary areas.

If these temporary areas are going to be used for storing of the turbine components and/or very heavy items that require the use of cranes, they will be considered as a usual WTG hardstand and analysed and designed in accordance with the Site-Specific Requirements (SSR) of each project.

This text must be kept intact in the project specific requirements. If the text cannot be kept, please contact the BOP Technical Office.

3.4. Safety distance from power lines

The Orders and Regulations in force in each country must be considered where high and low-voltage lines pass over the internal wind farm roads or wind farm access roads.

Distance limits for working areas are included as a reference.

U_n	D_{PEL-1}	D_{PEL-2}	D_{PROX-1}	D_{PROX-2}
≤ 1	50	50	70	300
3	62	52	112	300
6	62	53	112	300
10	65	55	115	300
15	66	57	116	300
20	72	60	122	300
30	82	66	132	300
45	98	73	148	300
66	120	85	170	300
110	160	100	210	500
132	180	110	330	500
220	260	160	410	500
380	390	250	540	700

Table 11. Safety distance from power lines to work areas

(Note)

The distances for intermediate voltage values will be calculated using linear interpolation.

Where:

- U_n - Rated voltage of the installation (kW).
- D_{PEL-1} - Distance to the outer limit of the danger area whenever there is a risk of voltage stressing due to lightning (cm).
- D_{PEL-2} - Distance to the outer limit of the danger area when there is no risk of overvoltage due to lightning (cm).
- D_{PROX-1} - Distance to the outer limit of the danger area whenever it is possible to mark out the work area accurately and control that this is not exceeded during the carrying-out of the work (cm).
- D_{PROX-2} - Distance to the outer limit of the danger area whenever it is not possible to mark out the work area accurately and control that this is not exceeded during the carrying-out of the work (cm).

This section (3.4.) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

4. Additional documentation

This document is of a general character, and it is necessary to include another document (e.g. External Note) specifying any additional requirements or revision/confirmation of the parameters of this document, in addition to:

- Number of WTGs.
- Turbine type. If there is more than one type, this should be specified position by position.
- Installation strategy and storage conditions. If there is more than one type, this should be specified position by position.
- Main, pre-assembly and assist crane proposed.
- Road width in the access road and between positions.
- Semi – mounted crane movement road requirements and affected road sections.
- Auxiliary means for transports as pull units. This should also include the road sections in which this auxiliary means are needed.
- Additional hardstands, in case needed (temporary storage).
- Confirmation of the widening curves table.
- Revision/confirmation of the parameters, e.g. KV, longitudinal gradients…
- Specification of dimension and other requirements of site facilities.
- Any other project specific requirements.

HSE, project by project, must also define their requirements. I.e. safety distances to the edge of the hardstands, in case there is a high difference in level.

To define the above information, receiving the Layout of the WF and other information is required.

This data will give a visualization of each wind turbine of the windfarm and it will convey any needed extra methods or measures in addition to the SGRE standards.

5. Annexes

5.1. Transport requirements

(Note): The data represented below is the result of the of the study was obtained from the modelling, showing the following widening according to the cargo and bed. The values are a reference considering the transport from the item ***3.1.5 Gradients and grade changes.*** For each windfarm and region, please bear in mind some changes could be possible. Concerning this, a new study must be done by Logistics department according with the transport available per region/project to avoid some nonconformities.

This section (5.1) cannot be removed in the project specific requirements, in case it does not apply it will be indicated as such.

VEHICLE: SG170, LEFT TURN

Radios (m)	10º			20º			30º			40º			50º			60º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	5	1,5	1,5	6	1,5	4,5	6	1,5	8	6	4	11	7	5,5	15	7	7	19
10	5	1,5	1,5	6	1,5	4,5	6	1,5	8	6	3,5	11	7	5,5	14,5	7	7	18
15	5	1,5	1,5	6	1,5	4,5	6	1,5	7,5	6	3,5	10,5	7	5	[illegible]	7	6,5	17,5
20	5	1,5	1,5	6	1,5	4,5	6	1,5	7,5	6	3,5	10,5	[illegible]	[illegible]	[illegible]	7	6	16,5
25	5	1,5	1	6	1,5	4,5	6	1,5	7,5	6	3	10	[illegible]	4,5	[illegible]	7	6	16
30	5	1,5	1	5	1,5	4,5	6	1,5	7	6	3	10	[illegible]	[illegible]	12,5	7	5,5	15
35	5	1,5	1	5	1,5	4	6	1,5	7	[illegible]	3	[illegible]	6	4	12	7	5,5	14,5
40	5	1,5	1	5	1,5	4	6	1,5	[illegible]	[illegible]	[illegible]	9	6	4	11,5	7	5	13,5
45	5	1,5	1	5	1,5	4	6	1,5	[illegible]	6	[illegible]	9	6	3,5	11	7	4,5	13
50	5	1,5	1	5	1,5	4	[illegible]	[illegible]	6,5	6	2,5	8,5	6	3,5	10,5	6	4,5	12
55	5	1,5	1	5	1,5	[illegible]	[illegible]	[illegible]	[illegible]	6	2,5	8	6	3,5	10	6	4	11,5
60	5	1,5	1	[illegible]	[illegible]	[illegible]	6	1,5	6	6	2	8	6	3	9,5	6	4	10,5
65	5	1,5	[illegible]	[illegible]	[illegible]	3,5	6	1,5	6	6	2	7,5	6	3	9	6	3,5	9,5
70	5	1,5	[illegible]	5	[illegible]	3,5	6	1,5	5,5	6	1,5	7,5	6	2,5	8,5	6	3,5	9
75	5	1,5	1	5	1,5	3,5	6	1,5	5,5	6	1,5	7	6	2,5	8	6	3	8
80	5	1,5	1	5	1,5	3,5	6	1,5	5,5	6	1,5	6,5	6	2	7,5	6	2,5	7,5
85	5	1,5	1	5	1,5	3,5	6	1,5	5	6	1,5	6,5	6	2	7	6	2	7
90	5	1,5	1	5	1,5	3,5	6	1,5	5	6	1,5	6	6	1,5	6,5	6	1,5	6,5

Radios (m)	70º			80º			90º			100º			110º			120º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	8	8	23,5	11	8	28	15	8	34	6	0	0	6	0	0	6	0	0
10	8	8	22	10	8	26,5	13	8	31,5	18	8	37,5	6	0	0	6	0	0
15	8	8	21	9	8	25	12	8	29,5	16	8	35	6	0	0	6	0	0
20	8	7,5	20	8	8	23,5	10	8	27,5	14	8	32	18	[illegible]	[illegible]	6	0	0
25	7	7	19	8	8	22	9	8	25	12	8	29	[illegible]	8	[illegible]	6	0	0
30	7	6,5	17,5	8	7,5	20,5	8	8	23	10	8	26	[illegible]	8	[illegible]	16	8,5	33
35	7	6,5	16,5	7	7	19	8	8	21	8	8	[illegible]	[illegible]	[illegible]	26	12	8,5	28
40	7	6	15,5	7	7	17,5	7	7,5	19	[illegible]	8	[illegible]	8	8	22	8	8,5	23
45	7	5,5	14,5	7	6	16	7	7	[illegible]	[illegible]	[illegible]	18	7	7,5	18,5	7	7,5	18,5
50	7	5	13,5	7	5,5	14,5	7	6	[illegible]	7	6,5	15,5	7	6,5	15,5	7	6,5	15,5
55	7	4,5	12,5	7	5	13	[illegible]	[illegible]	[illegible]	7	5,5	13	7	5,5	13	7	5,5	13
60	6	4,5	11	6	4,5	[illegible]	[illegible]	[illegible]	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	[illegible]	[illegible]	[illegible]	6	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	[illegible]	[illegible]	[illegible]	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	[illegible]	6	[illegible]	8,5	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5
80	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5
85	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7
90	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5

Radios (m)	130º			140º			150º			160º			170º			180º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
10	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
15	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
20	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
25	6	0	0	6	0	0	6	0	0	6	0	0	[illegible]	0	[illegible]	[illegible]	0	0
30	6	0	0	6	0	0	6	0	0	6	0	[illegible]	[illegible]	[illegible]	[illegible]	6	0	0
35	15	8,5	31	19	8,5	35	6	0	0	[illegible]	0	[illegible]	6	[illegible]	0	6	0	0
40	9	8,5	24	11	8,5	25,5	12	8,5	26	[illegible]	8,5	[illegible]	16	8,5	29	18	8,5	31
45	7	7,5	18,5	7	7,5	18,5	8	[illegible]	[illegible]	8	[illegible]	18,5	8	7,5	18,5	8	7,5	18,5
50	7	6,5	15,5	7	6,5	15,5	7	6,5	[illegible]	7	6,5	15,5	7	6,5	15,5	7	6,5	15,5
55	7	5,5	13	7	5,5	[illegible]	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13
60	6	5	11,5	6	5	[illegible]	6	5	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	6	4	[illegible]	6	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	9	[illegible]	[illegible]	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5
80	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5
85	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7
90	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5

SIEMENS Gamesa
RENEWABLE ENERGY

VEHICLE: SG170, RIGHT TURN

Radios (m)	10º			20º			30º			40º			50º			60º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	5	4	2,5	6	6	5,5	6	7,5	8,5	6	9	11,5	7	10	15,5	7	10,5	19
10	5	4	2,5	6	6	5,5	6	7,5	8,5	6	8,5	11,5	7	9,5	15	7	10,5	18
15	5	4	2,5	6	5,5	5	6	7,5	8,5	6	8,5	11	7	9,5	14	7	10,5	17,5
20	5	4	2	6	5,5	5	6	7,5	8	6	8,5	11	[illegible]	[illegible]	14	7	10	16,5
25	5	4	2	6	5,5	5	6	7,5	8	6	8,5	10,5	7	[illegible]	[illegible]	7	10	16
30	5	4	2	5	5,5	5	6	7	7,5	6	[illegible]	[illegible]	[illegible]	9	13	7	10	15,5
35	5	4	2	5	5,5	5	6	7	7,5	[illegible]	[illegible]	10	6	9	12,5	7	9,5	14,5
40	5	4	2	5	5,5	5	6	7	[illegible]	6	[illegible]	[illegible]	6	9	12	7	9,5	14
45	5	4	2	5	5,5	5	6	7	[illegible]	6	8	9,5	6	8,5	11,5	7	9,5	13,5
50	5	4	2	5	5,5	4,5	[illegible]	7	[illegible]	[illegible]	8	9	6	8,5	11	6	9	12,5
55	5	4	2	5	5,5	4,5	[illegible]	[illegible]	7	6	8	9	6	8,5	10,5	6	9	11,5
60	5	4	2	[illegible]	[illegible]	4,5	[illegible]	6,5	6,5	6	7,5	8,5	6	8,5	10	6	9	11
65	5	4	[illegible]	5	[illegible]	4,5	6	6,5	6,5	6	7,5	8	6	8	9,5	6	8,5	10,5
70	5	4	2	5	[illegible]	4,5	6	6,5	6,5	6	7,5	8	6	8	9	6	8,5	9,5
75	5	4	[illegible]	[illegible]	5,5	4,5	6	6,5	6	6	7	7,5	6	7,5	8,5	6	8	9
80	5	4	[illegible]	5	5,5	4,5	5	6,5	6	5	7	7,5	6	7,5	8	6	7,5	8
85	5	4	2	5	5,5	4	5	6,5	6	5	7	7	6	7,5	7,5	6	7,5	7,5
90	5	4	2	5	5,5	4	5	6,5	5,5	5	7	6,5	6	7	7	6	7	7

Radios (m)	70º			80º			90º			100º			110º			120º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	8	11	23,5	11	11	28	15	11	34									
10	8	11	22	10	11	26,5	13	11	31,5	18	11	37,5						
15	8	10,5	21	9	11	25	12	11	29,5	16	11	35						
20	8	10,5	20	8	11	23,5	10	11	27,5	14	11	[illegible]	18	[illegible]	37,5			
25	7	10,5	19	8	11	22	9	11	25	12	11	29	15	[illegible]	33			
30	7	10,5	17,5	8	10,5	20,5	8	11	23	10	[illegible]	[illegible]	[illegible]	11	29	16	11	33
35	7	10	16,5	7	10,5	19	8	11	[illegible]	[illegible]	[illegible]	23,5	10	11	26	12	11	28
40	7	10	15,5	7	10,5	17,5	7	[illegible]	19	[illegible]	11	20,5	8	11	22	8	11	23
45	7	9,5	14,5	7	10	16	[illegible]	10,5	[illegible]	7	10,5	18	7	10,5	18,5	7	10,5	18,5
50	7	9,5	13,5	7	9,5	14,5	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	12,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	11,5	6	[illegible]	12	6	9	12	6	9	12	6	9	12	6	9	12
65	6	8,5	10,5	6	[illegible]	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5
75	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9
80	6	7,5	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5
85	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5
90	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7

Radios (m)	130º			140º			150º			160º			170º			180º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5																		
10																		
15																		
20																		
25																		
30																		
35	15	11	31	19	11	35												
40	9	11	24	11	11	25,5	[illegible]	11	[illegible]	[illegible]	11	27	16	11	29	18	11	31
45	7	10,5	18,5	7	10,5	18,5	8	[illegible]	18,5	8	10,5	18,5	8	10,5	18,5	8	10,5	18,5
50	7	10	15,5	7	[illegible]	15,5	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	13,5	7	[illegible]	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	12	6	[illegible]	12	6	9	12	6	9	12	6	9	12	6	9,5	12
65	6	9	[illegible]	[illegible]	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	[illegible]	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	10
75	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9
80	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5
85	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5
90	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7,5	7

5.2. Quality tests and requirements for civil works projects

The quality control and the requirements for the civil works design is defined according to the ***GD483525-EN, Quality Test Plan for Roads and Hardstands.***

!	**This text (5.2.) must be kept intact in the project specific requirements and can only be adapted to the local standard, if any, for these specific low volume roads.**

5.3. Legislations

Siemens Gamesa and its affiliates reserve the right to change the above specifications without prior notice.

5.4. Additional documentation

The following additional documentation is subject to customer requirement:

- ***GD483525-EN, Quality Test Plan for Roads and Hardstands.***

5.5. Hardstand dimensions

The sizing of the hardstands is defined by the use of the standard crane LG1750.

5.5.1. T100m tubular steel tower Hardstand with strategy 3

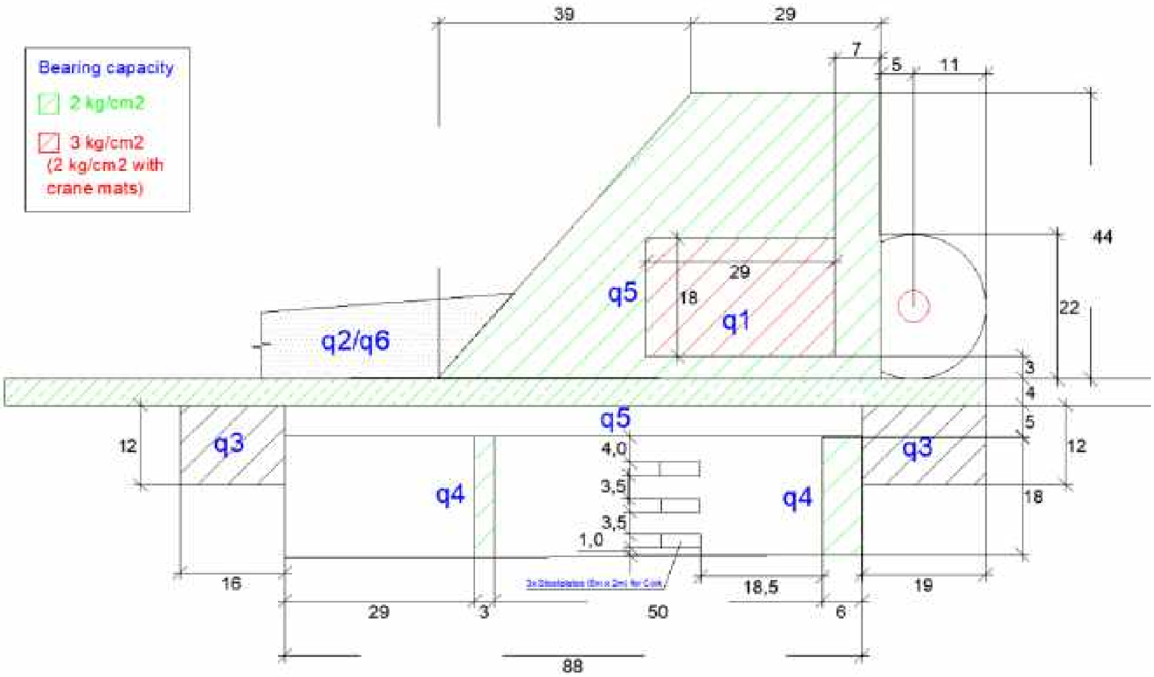
- Tailing crane offloading T100m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 29m x 44m + (39m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 26m x 44m + (35m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 27. Dimensions of the areas of model T100m with strategy 3 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1 phase



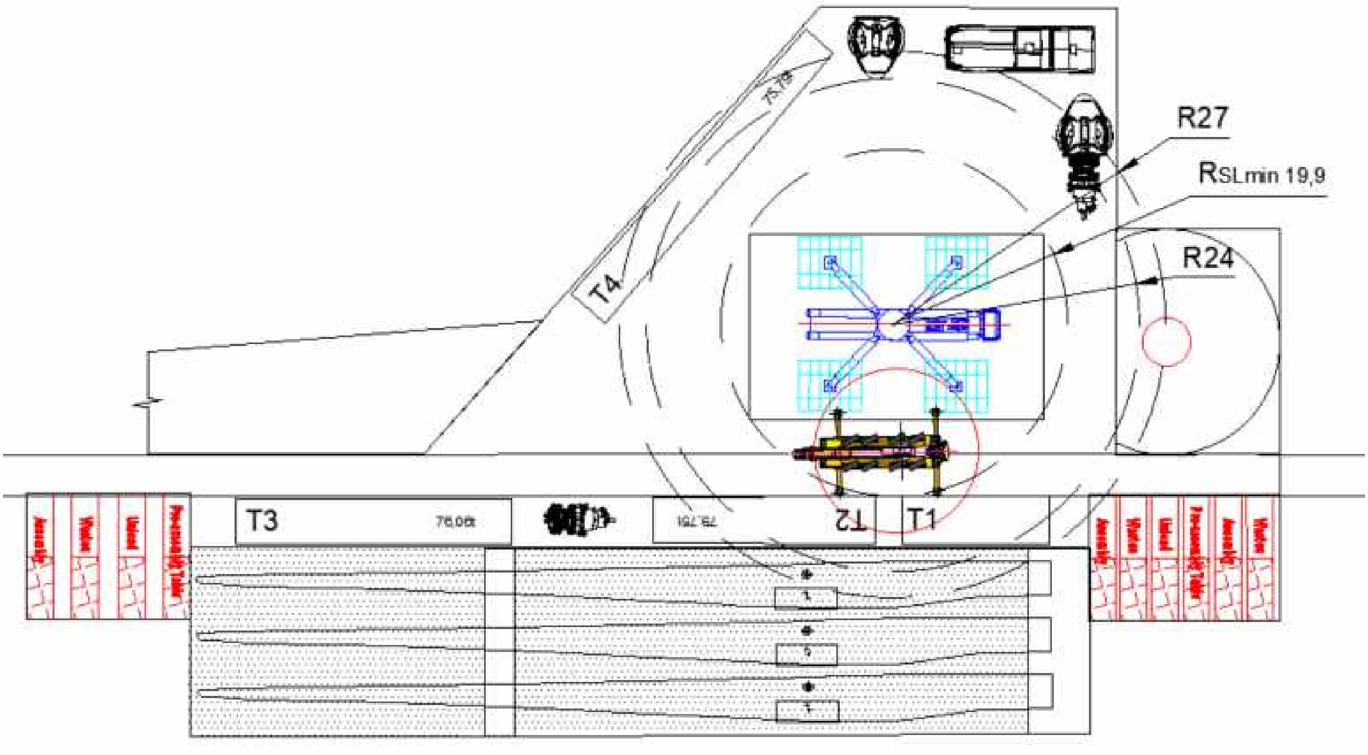
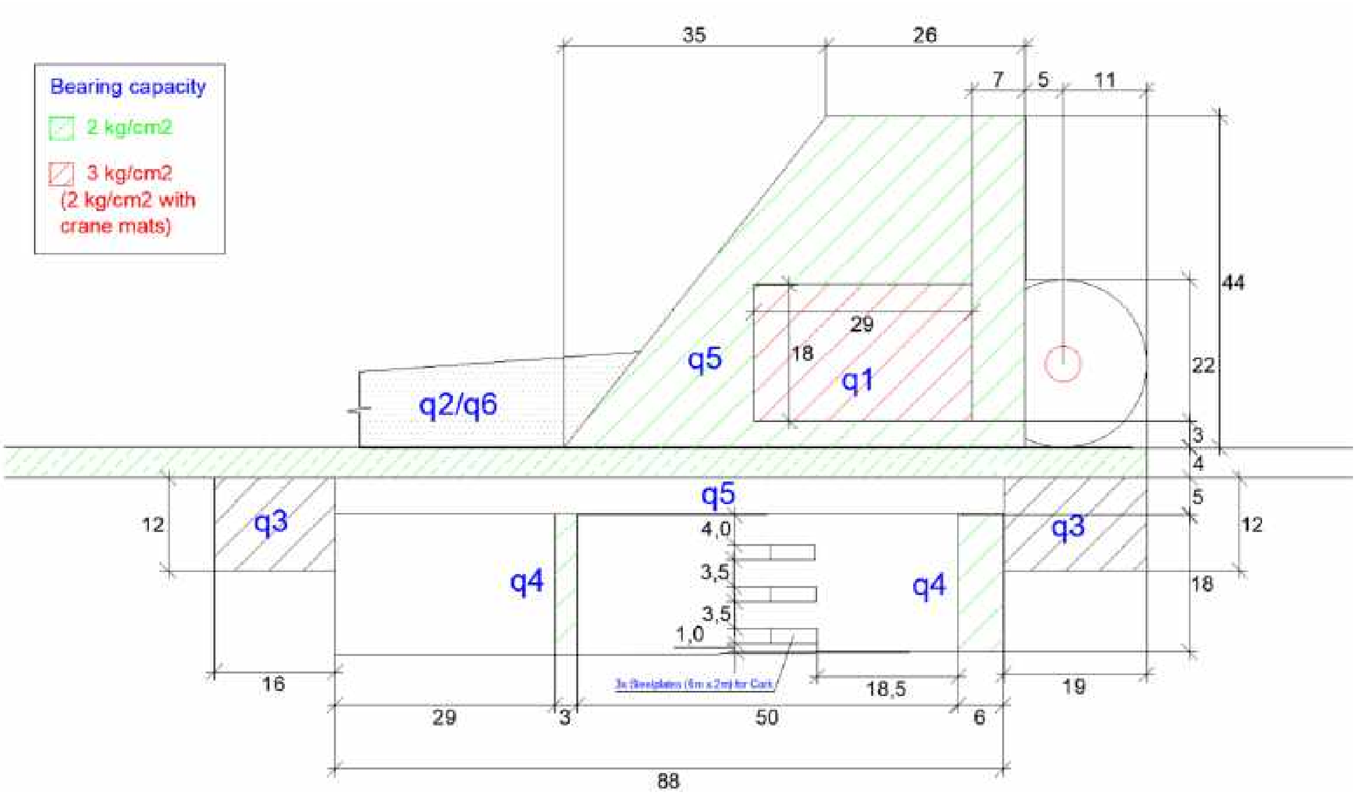
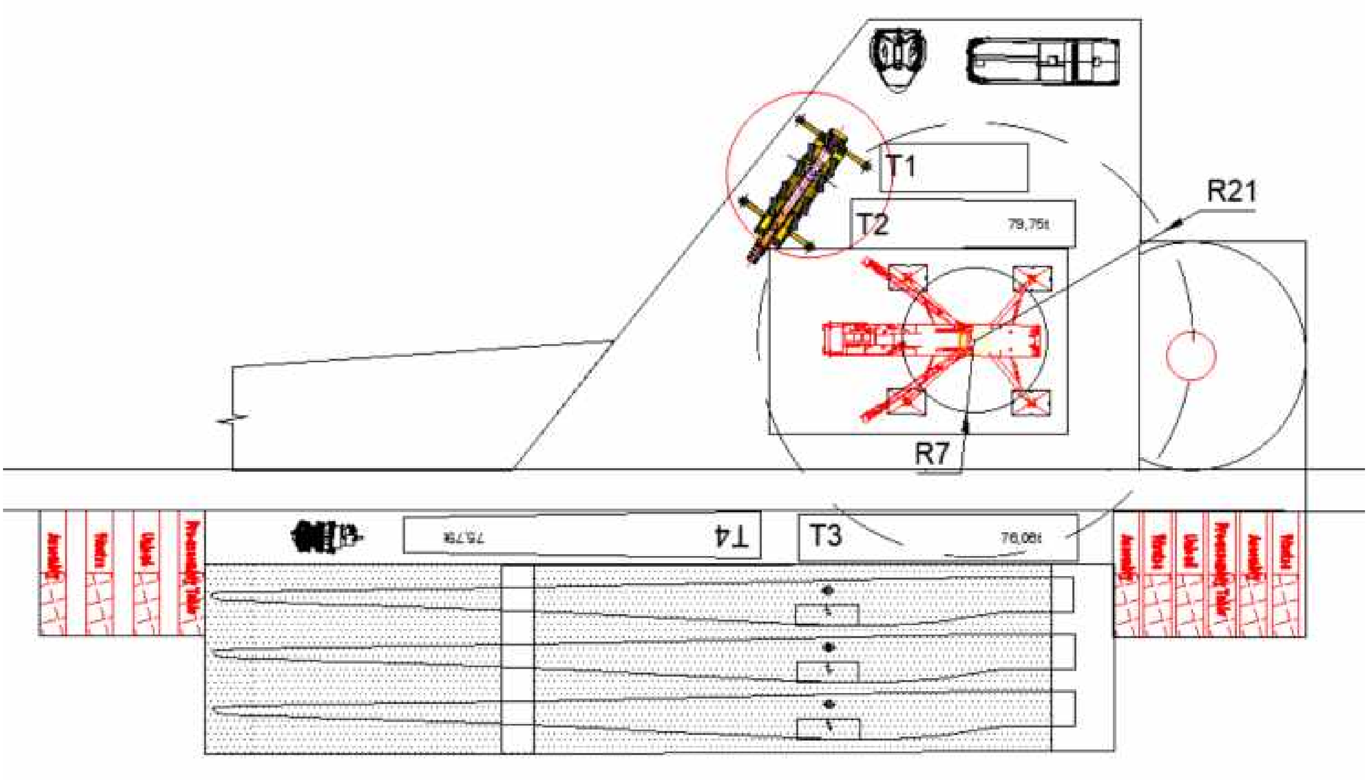


Figure 10 Model T100m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE Standard)





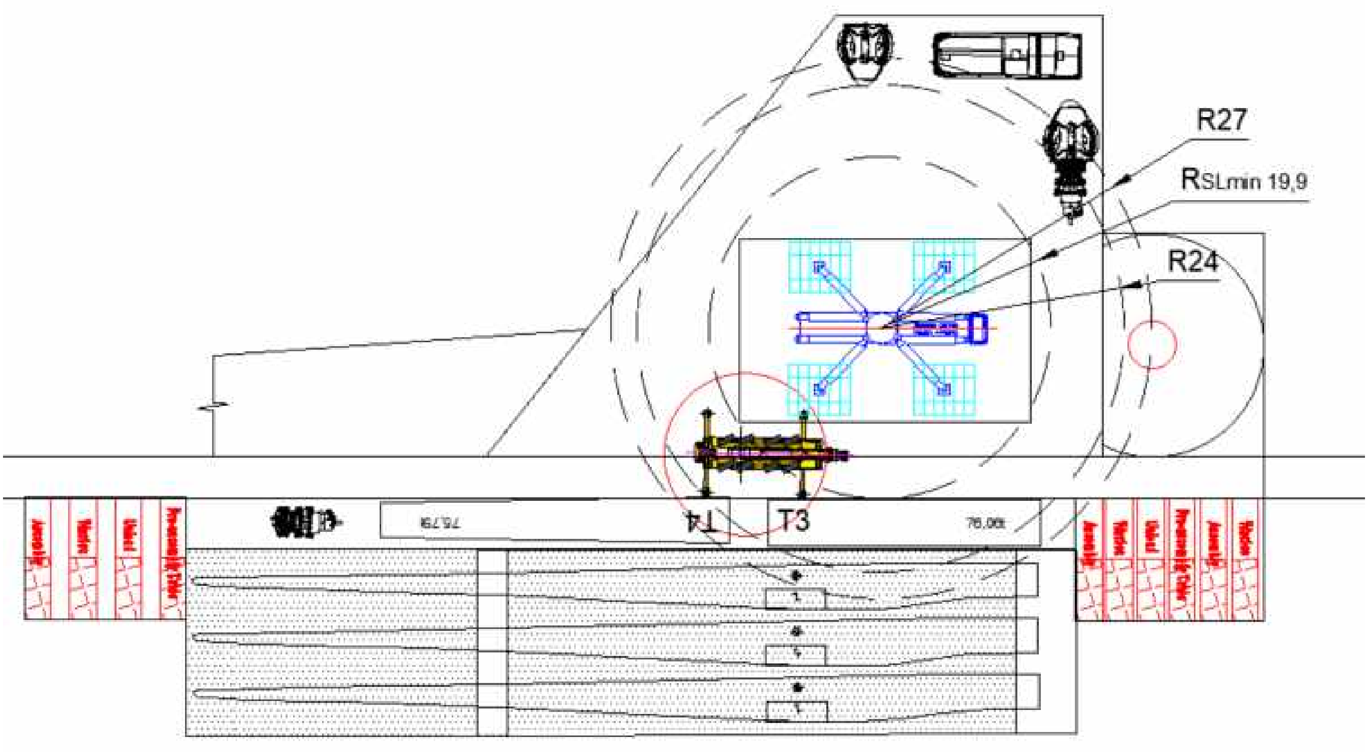


Figure 11 Model T100m – Partial storage assembling with strategy 3 in 2 phases

5.5.2. T100m tubular steel tower Hardstand with strategy 4

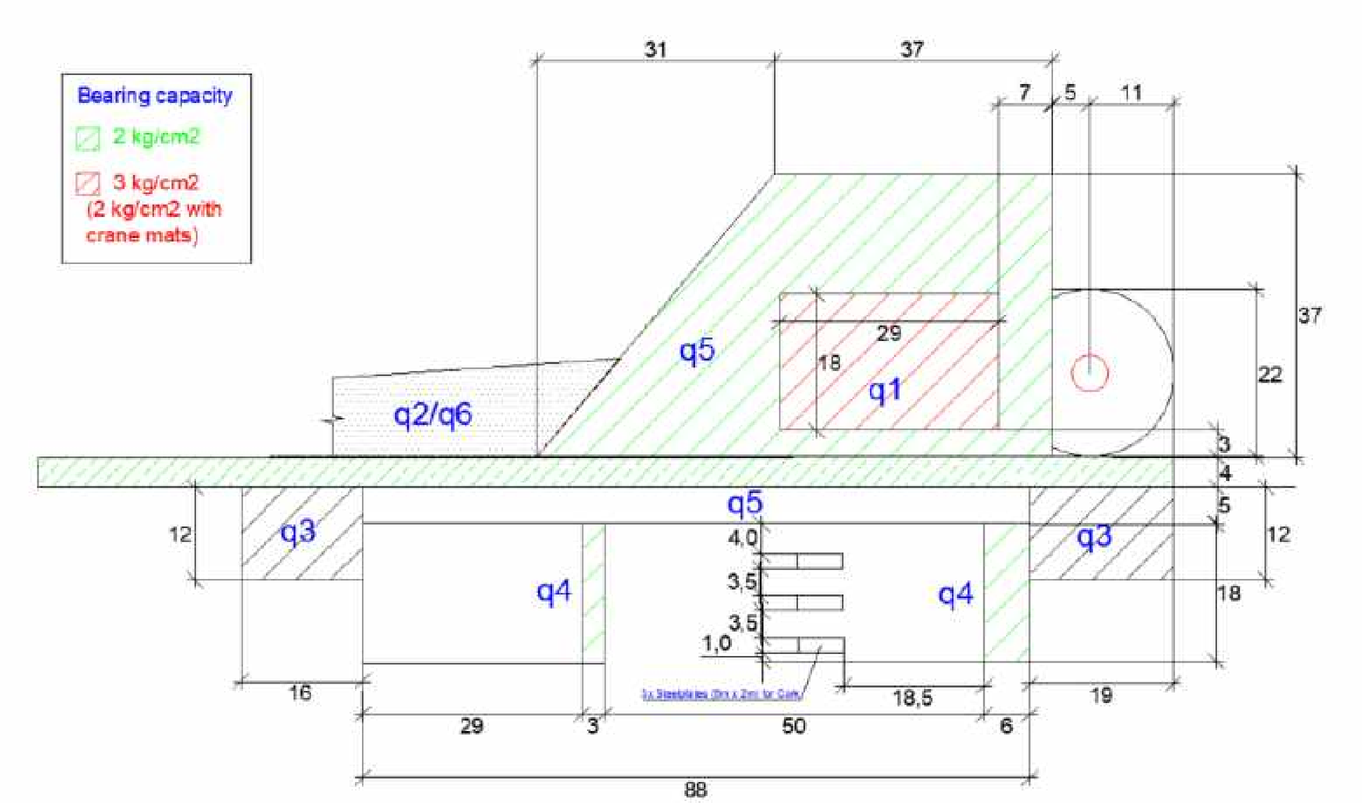
- Tailing crane offloading T100m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 37m x 37m + (31m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 29m x 39m + (32m x 39m)/2 – q1+ 88m x 5m + reinforced road part* q2/q6: dimensions according to the3.2.7. Requirements for assembly the main crane

Table 28. Dimensions of the areas of model T100m with strategy 4 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1 phase



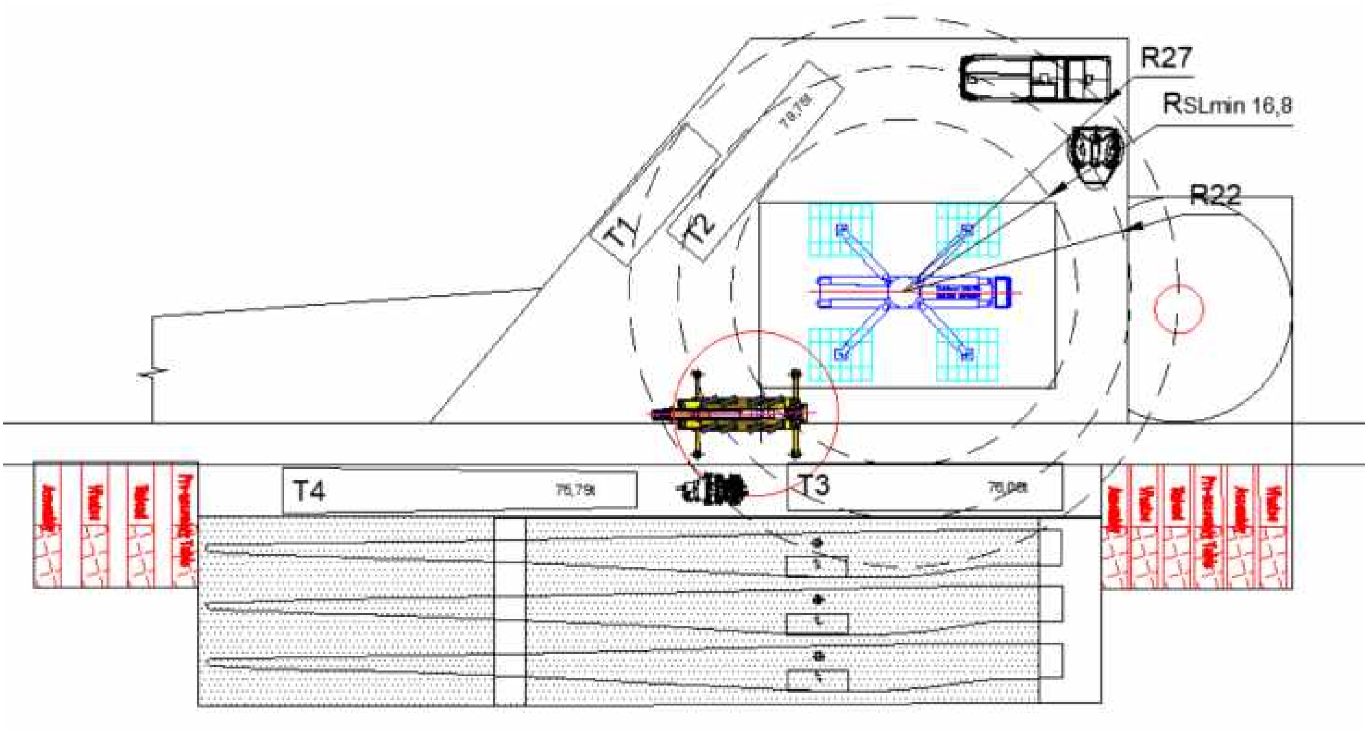
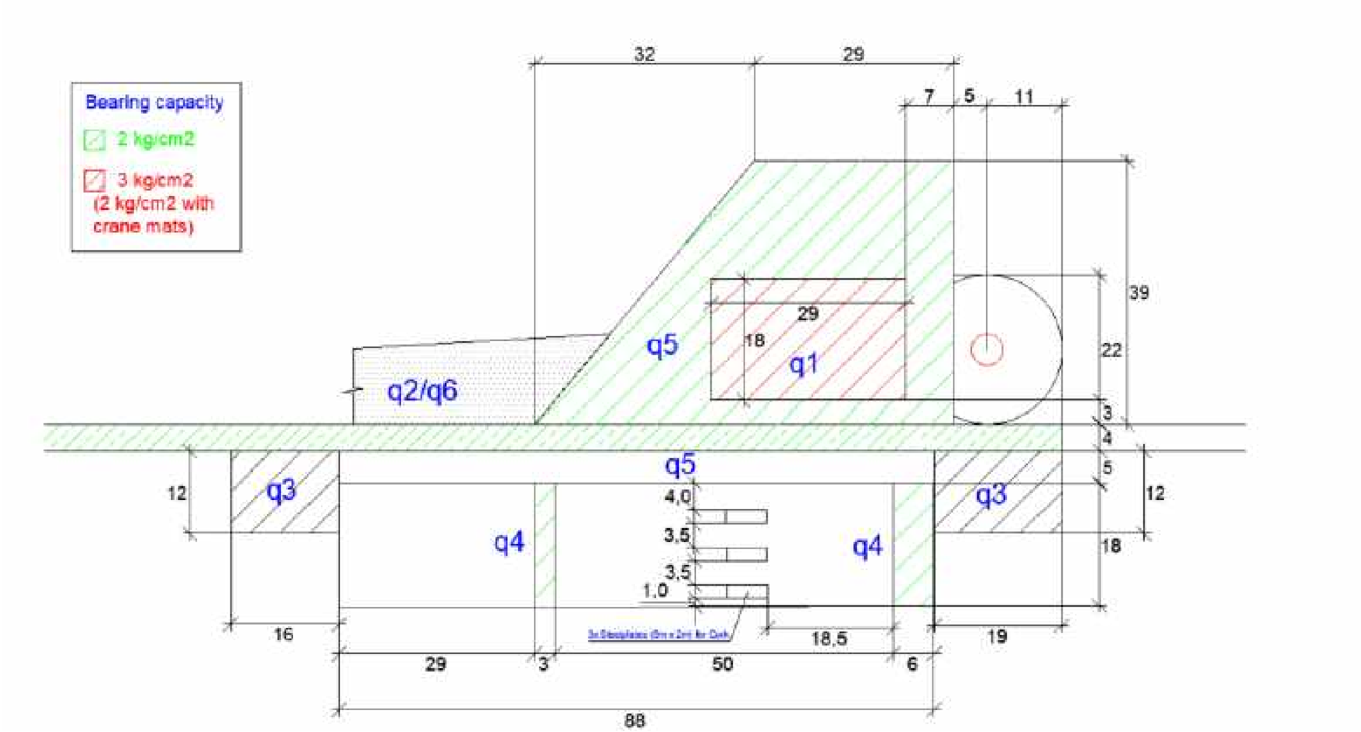
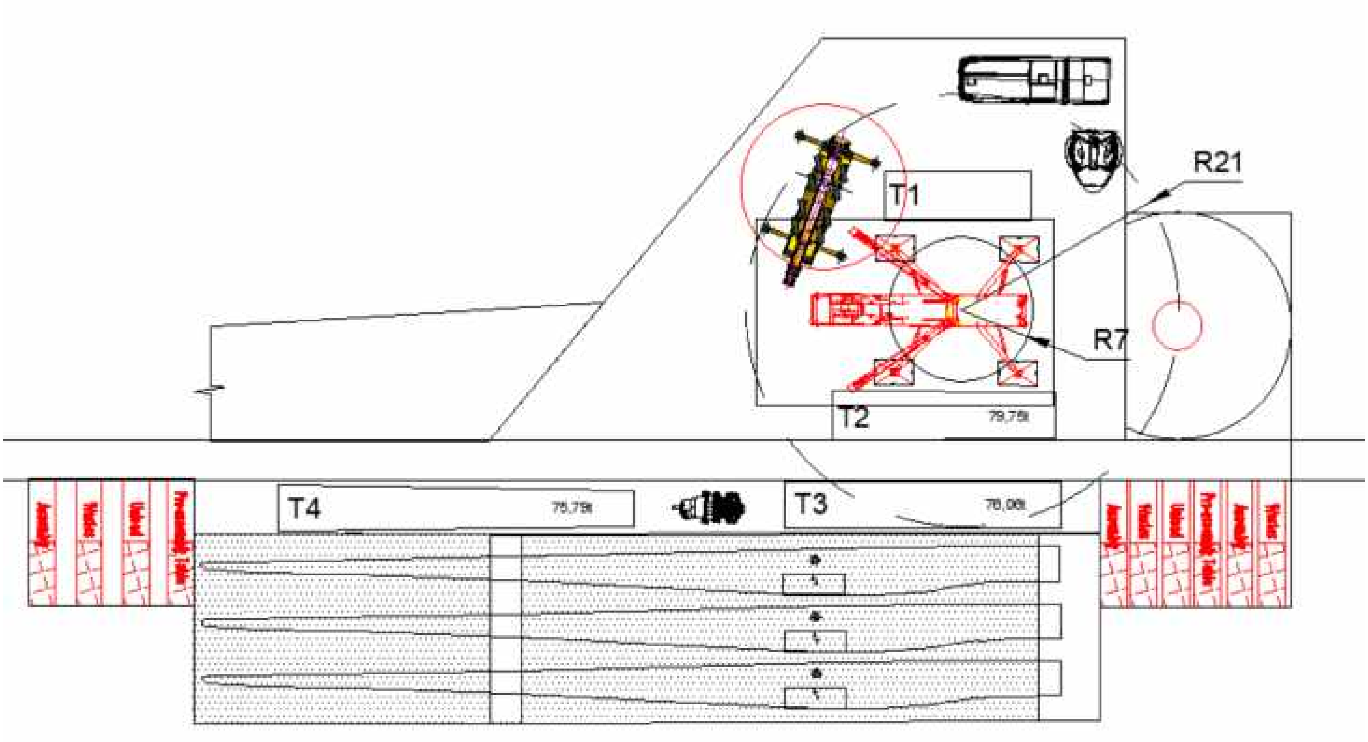


Figure 12 Model T100m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)





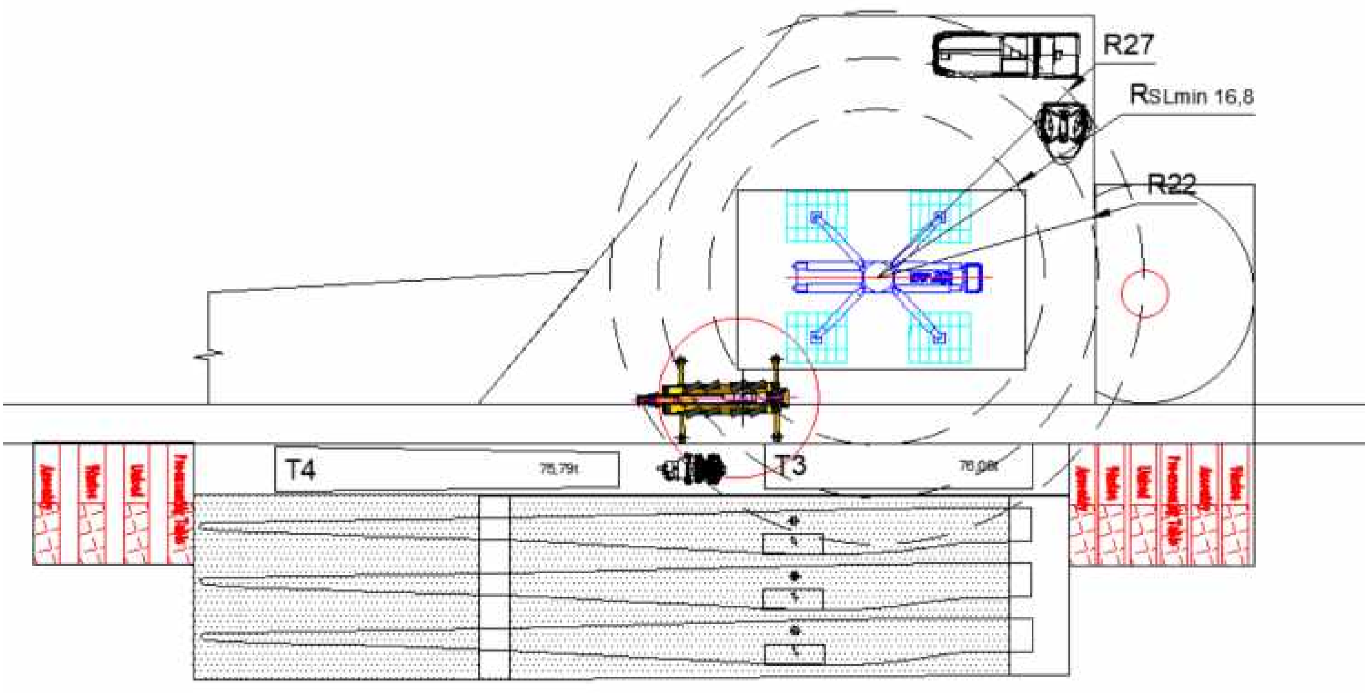


Figure 13 Model T100m – Partial storage assembling with strategy 4 in 2 phases

5.5.3. T110.5m tubular steel tower Hardstand with strategy 3

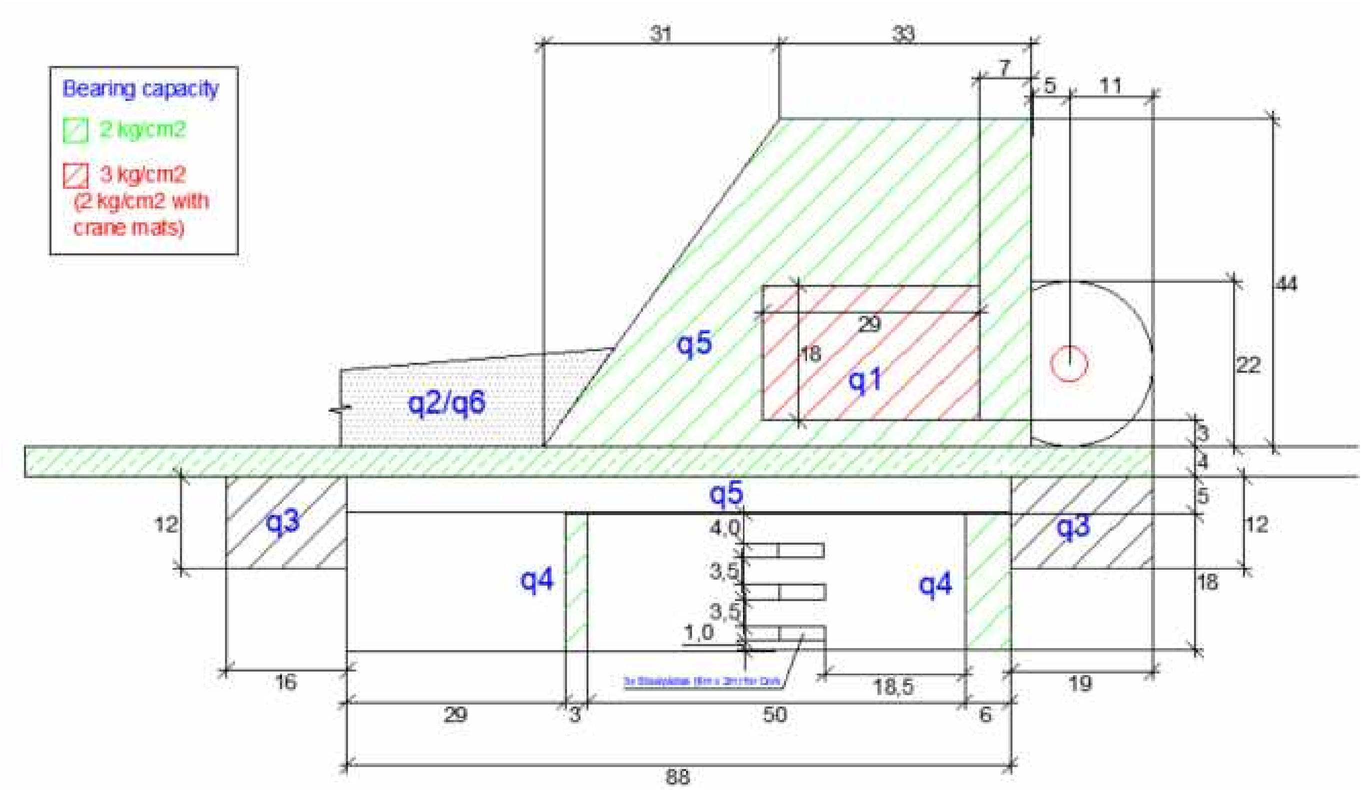
- Tailing crane offloading 110.5m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 33m x 44m + (31m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 27m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 29. Dimensions of the areas of model T110.5m with strategy 3 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1 phase



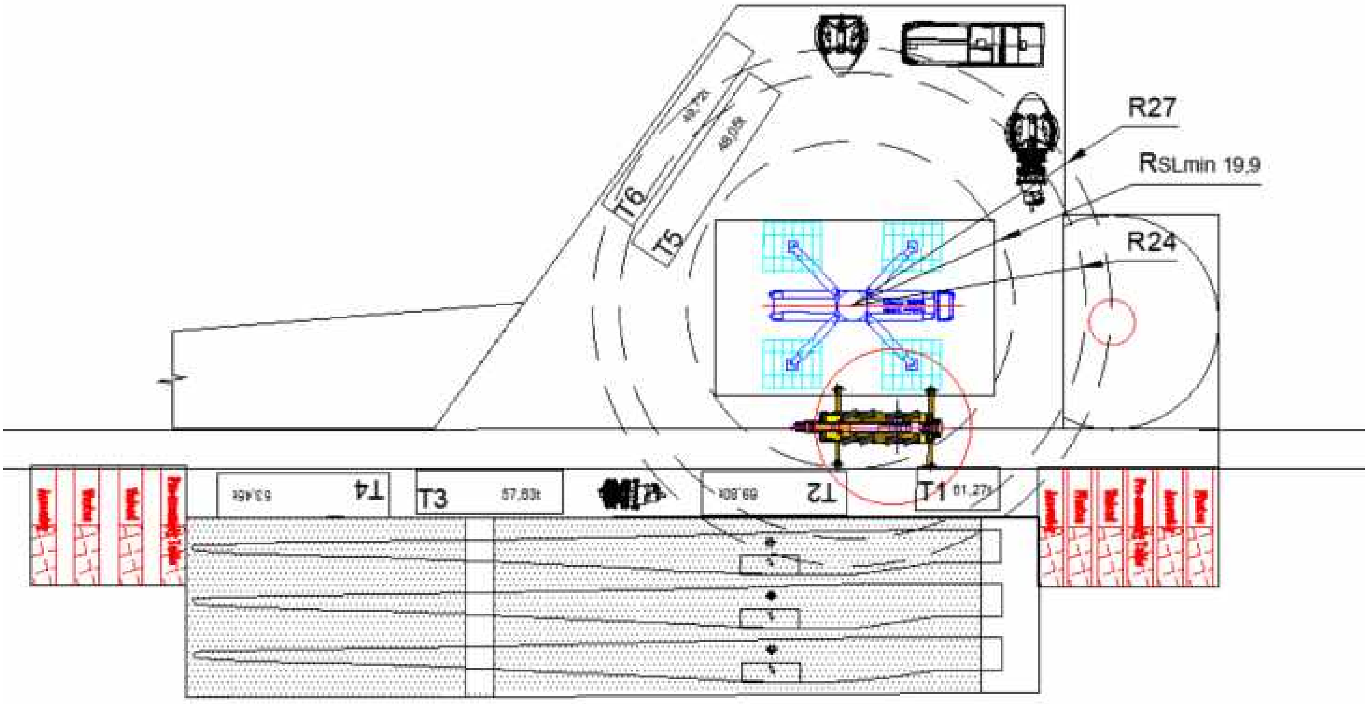
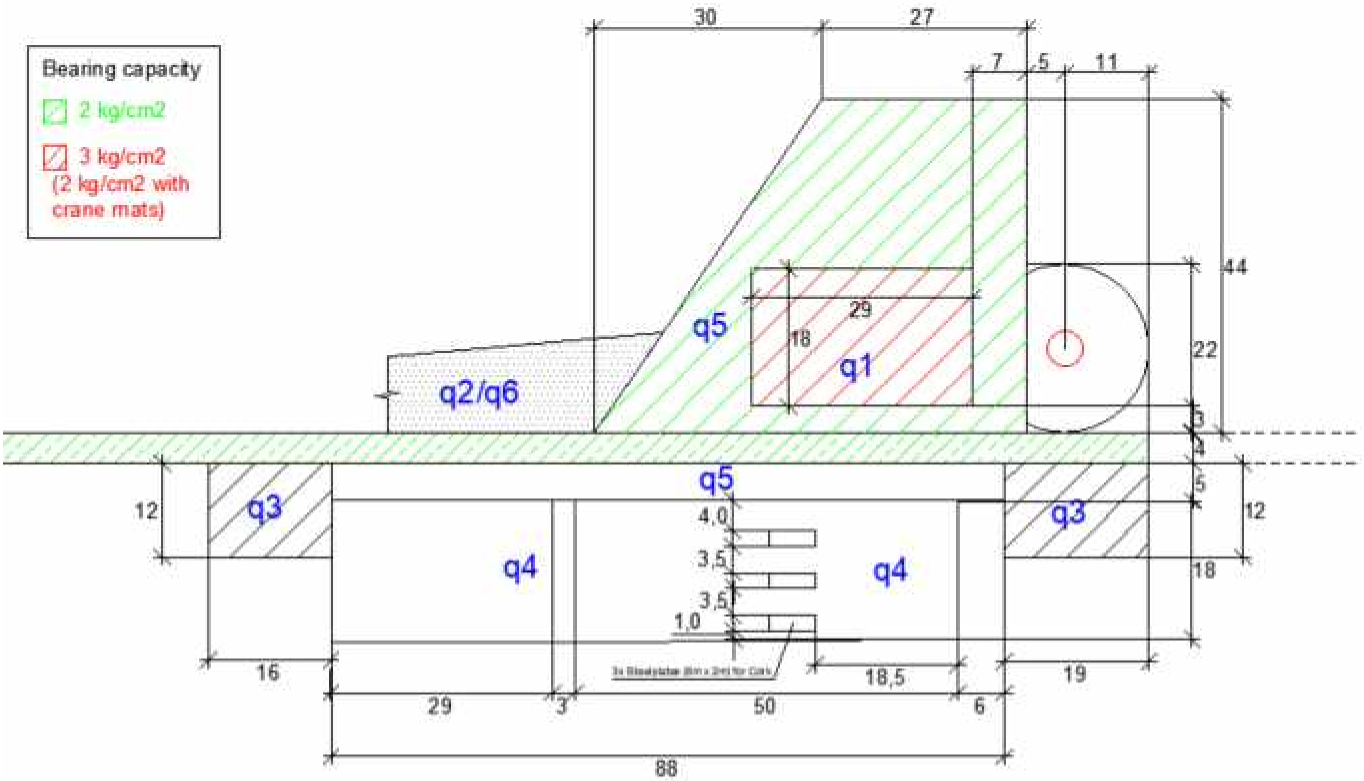


Figure 14 Model T110.5m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE Standard)



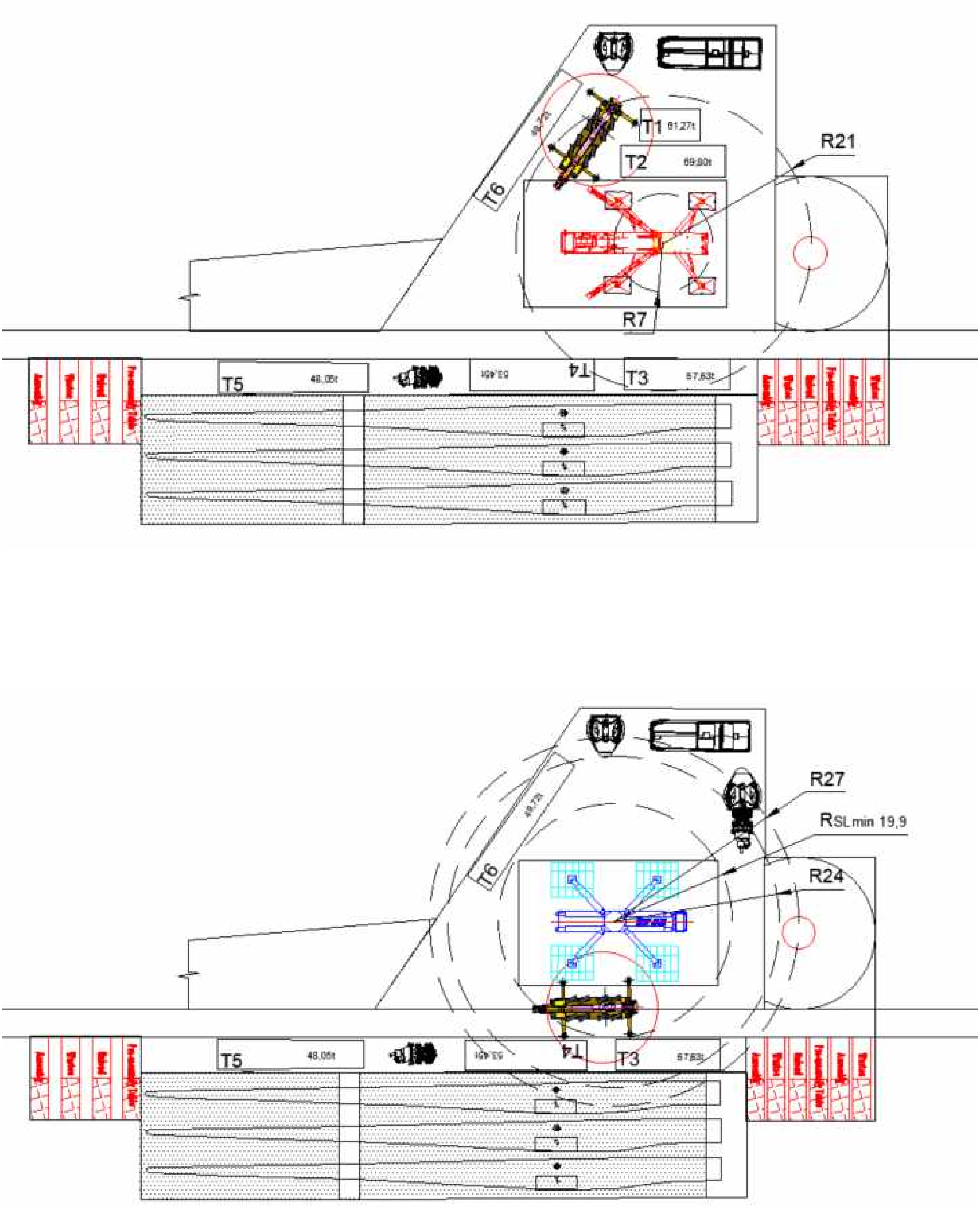


Figure 15 Model T110.5m – Partial storage assembling with strategy 3 in 2 phases

5.5.4. T110.5m tubular steel tower Hardstand with strategy 4

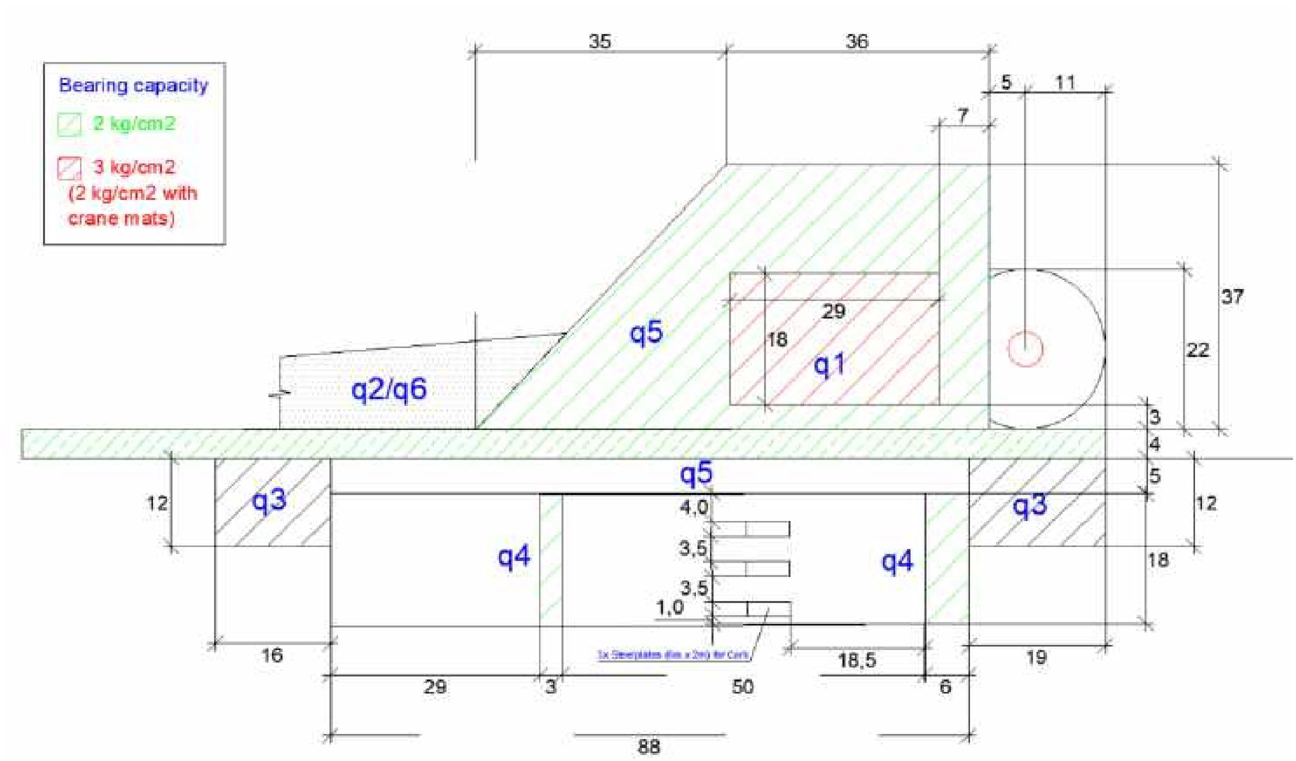
- Tailing crane offloading T110.5m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 36m x 37m + (35m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 28m x 37m + (35m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 30.12 Dimensions of the areas of model T110.5m with strategy 4 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1 phase



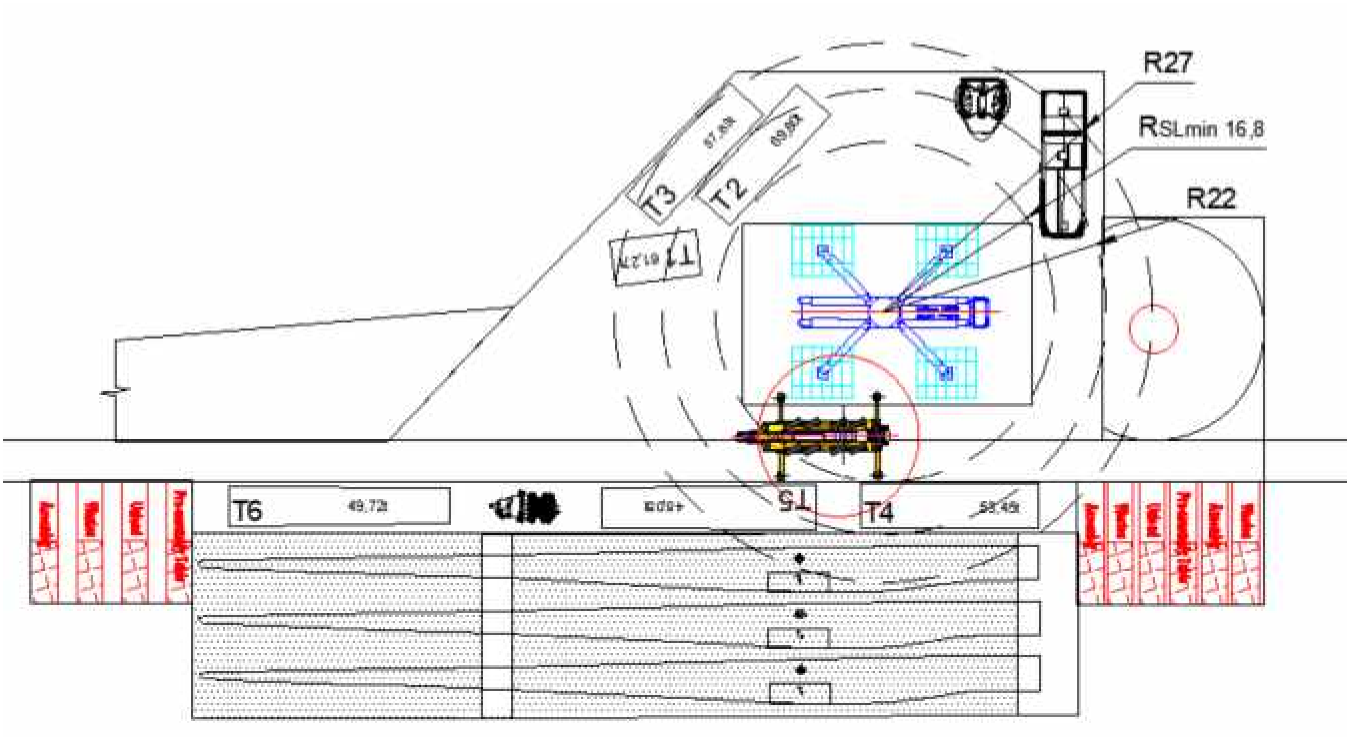
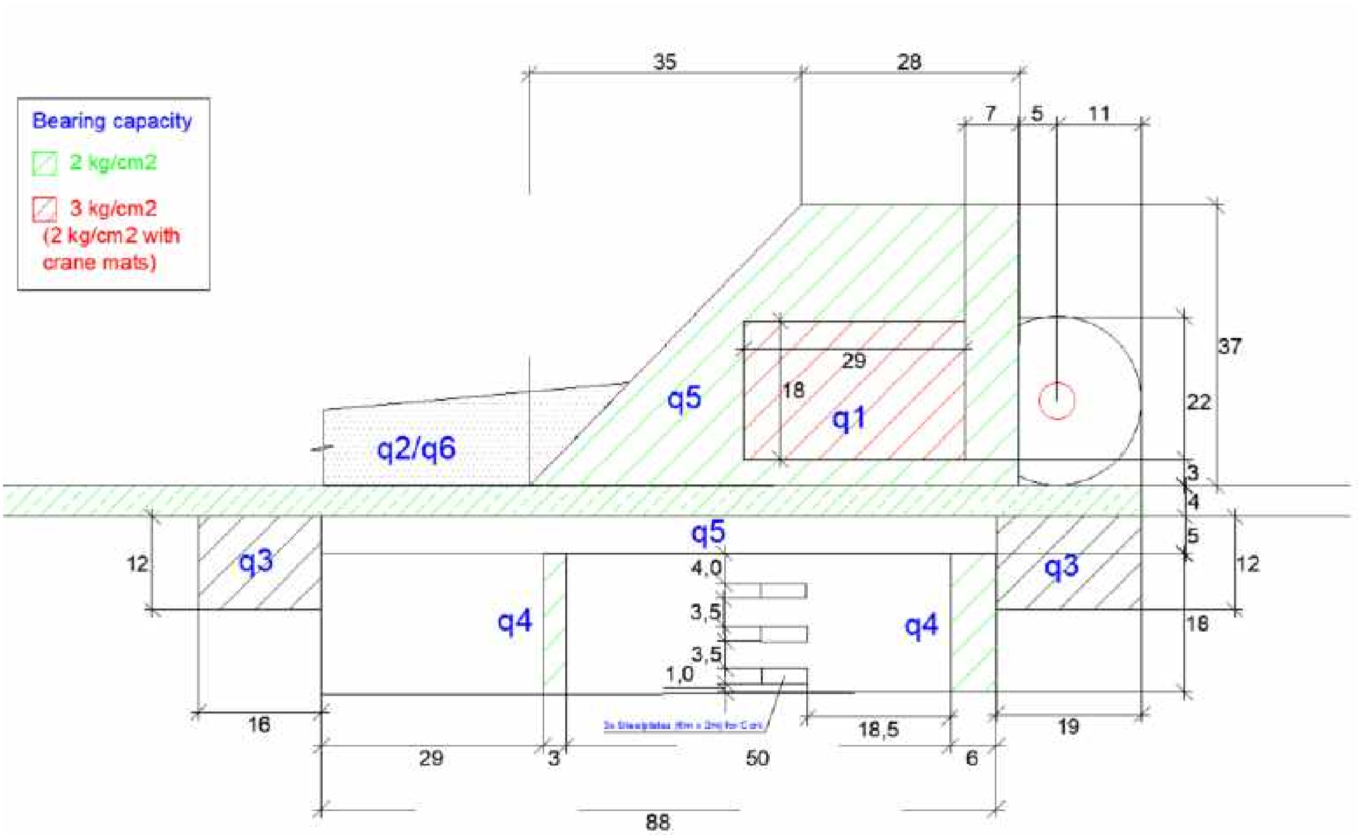


Figure 16 Model T110.5m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



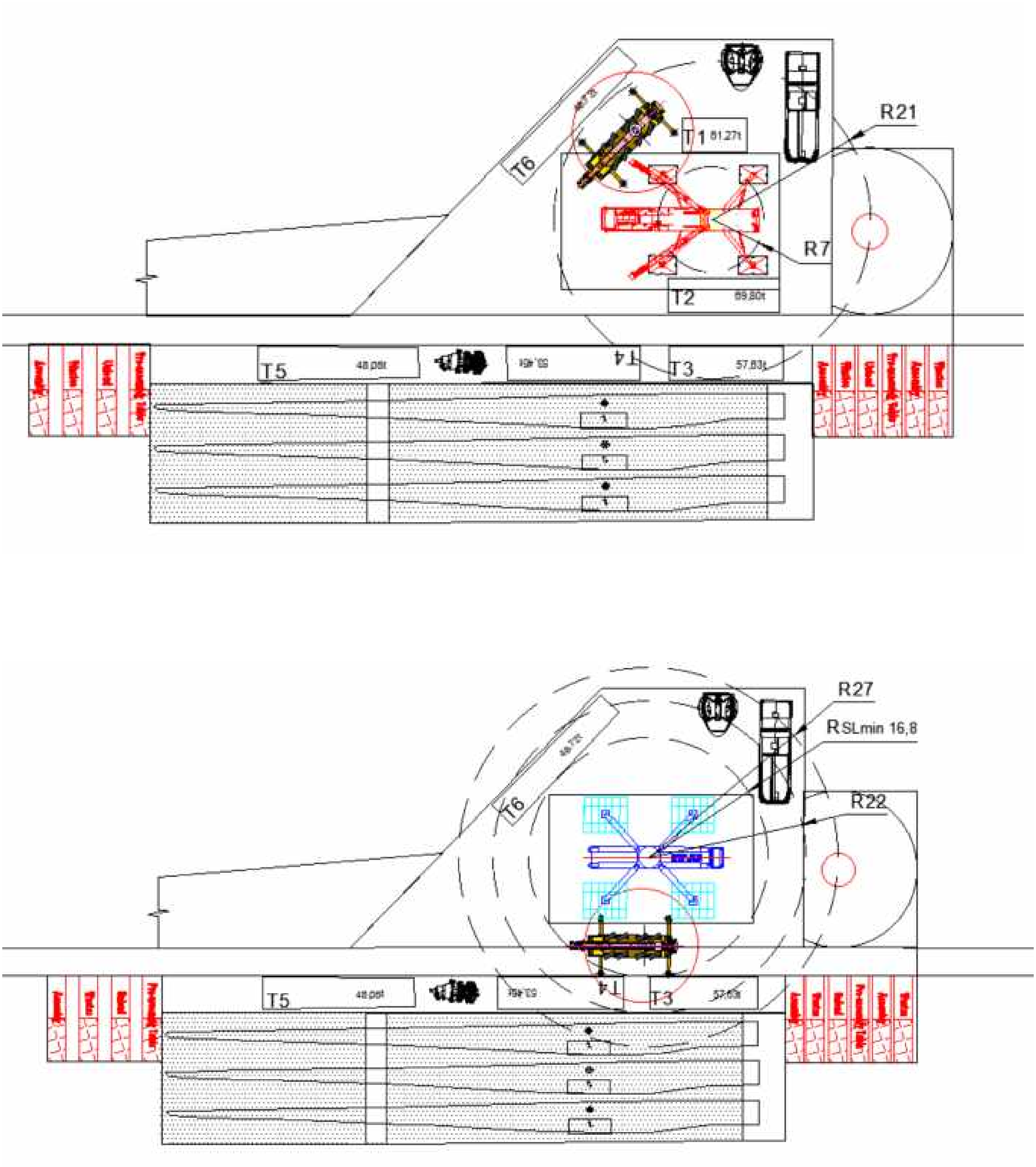


Figure 17 Model T110.5m – Partial storage assembling with strategy 4 in 2 phases

5.5.5. T115m tubular steel tower Hardstand with strategy 3

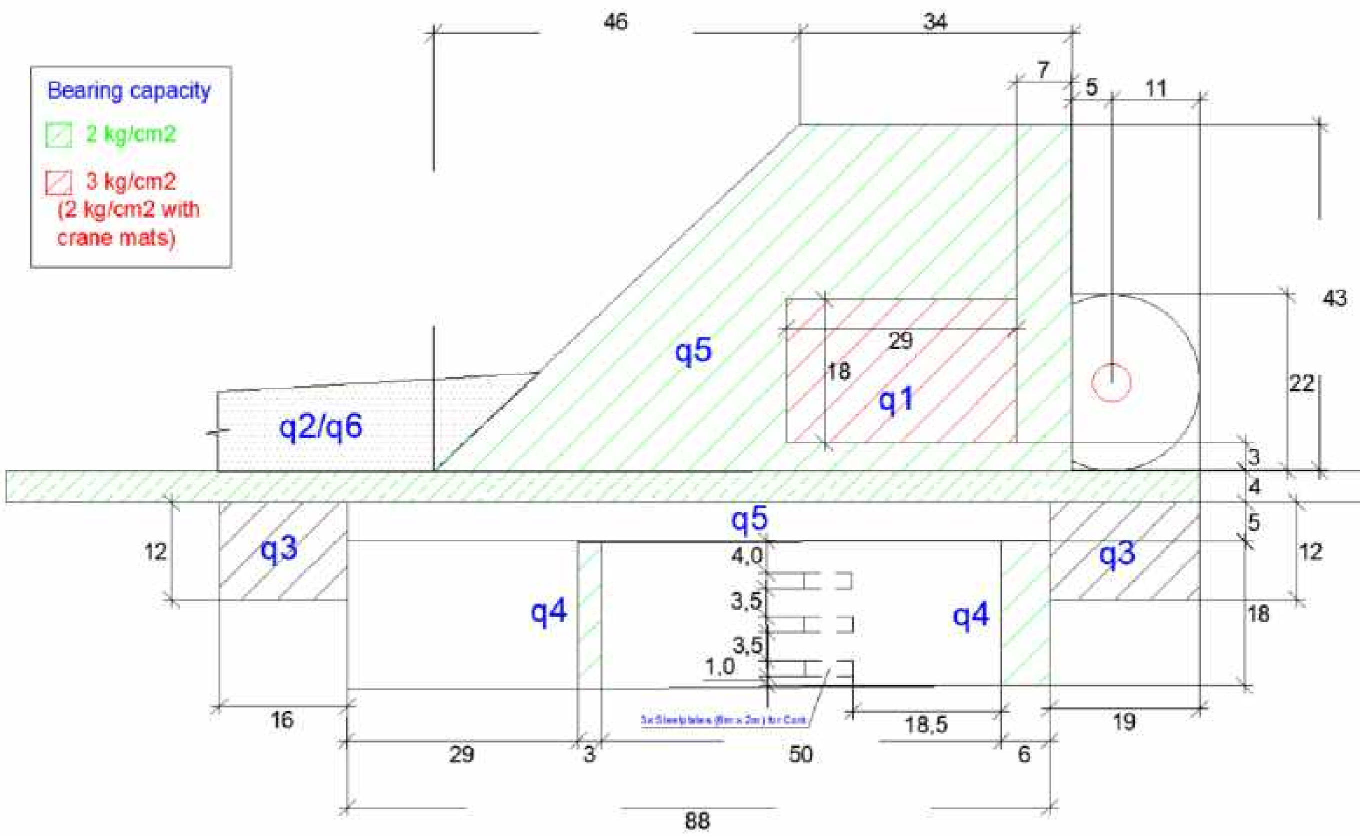
- Tailing crane offloading T115m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 34m x 43m + (46m x 43m)/2 – q1 +88m x 5m + reinforced road part* q2/q6 dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 33m x 43m + (36m x 43m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 31. Dimensions of the areas of model T115m with strategy 3 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – assembly in 1 phase



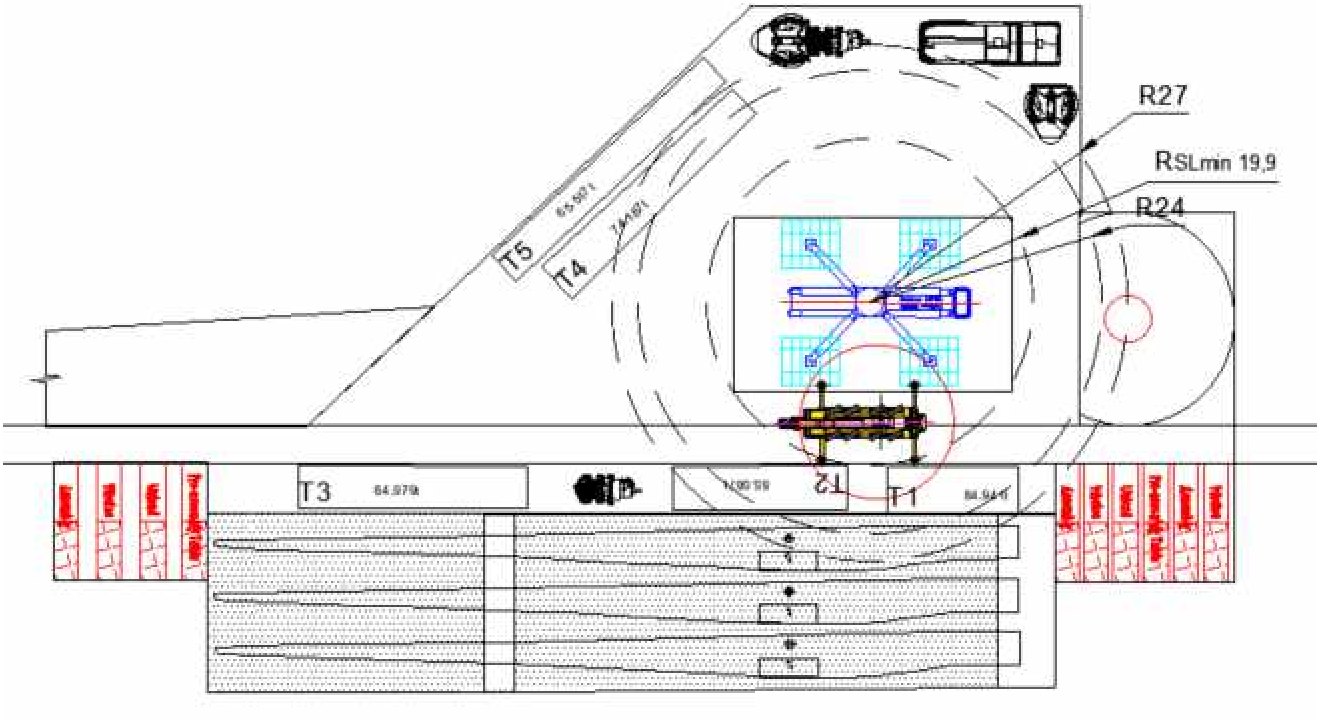
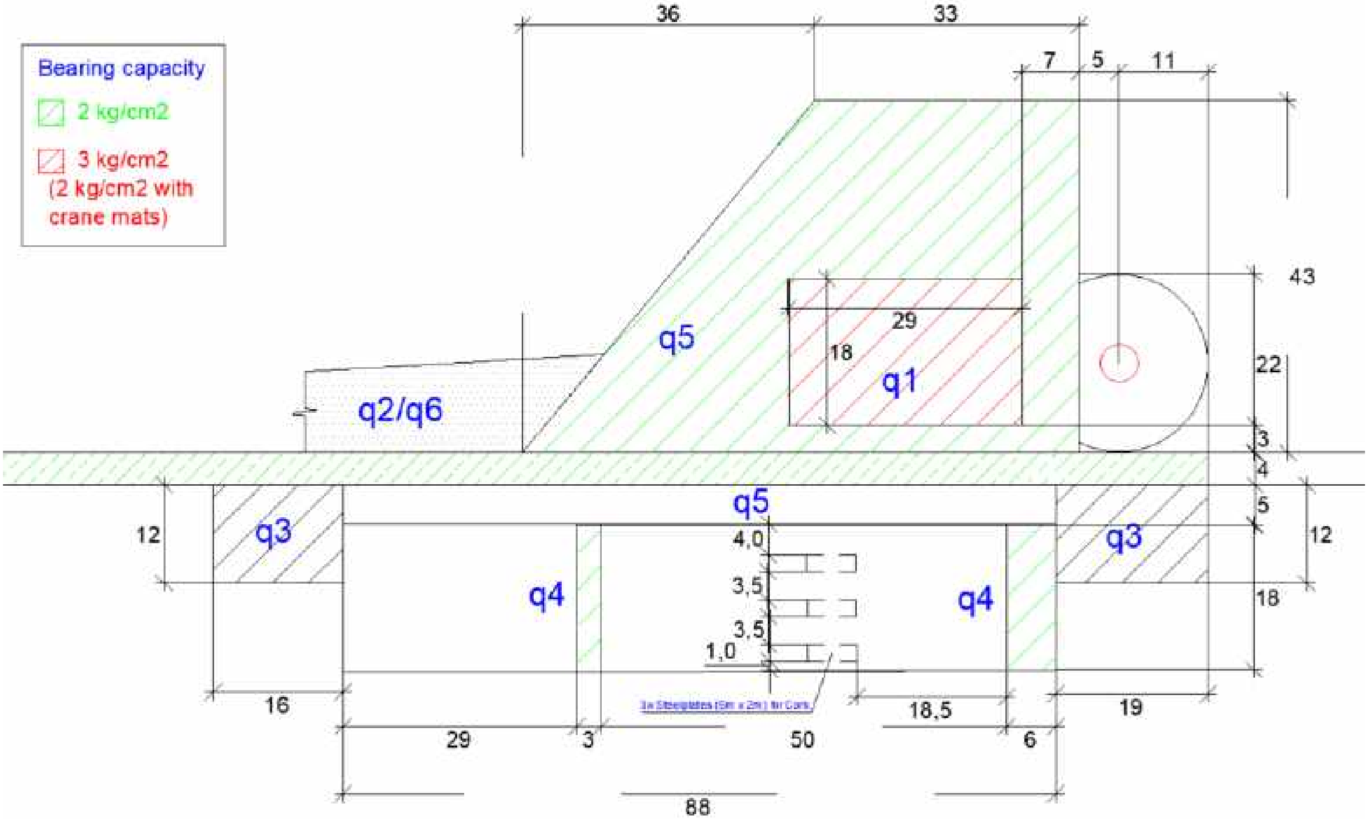


Figure 18 Model T115m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



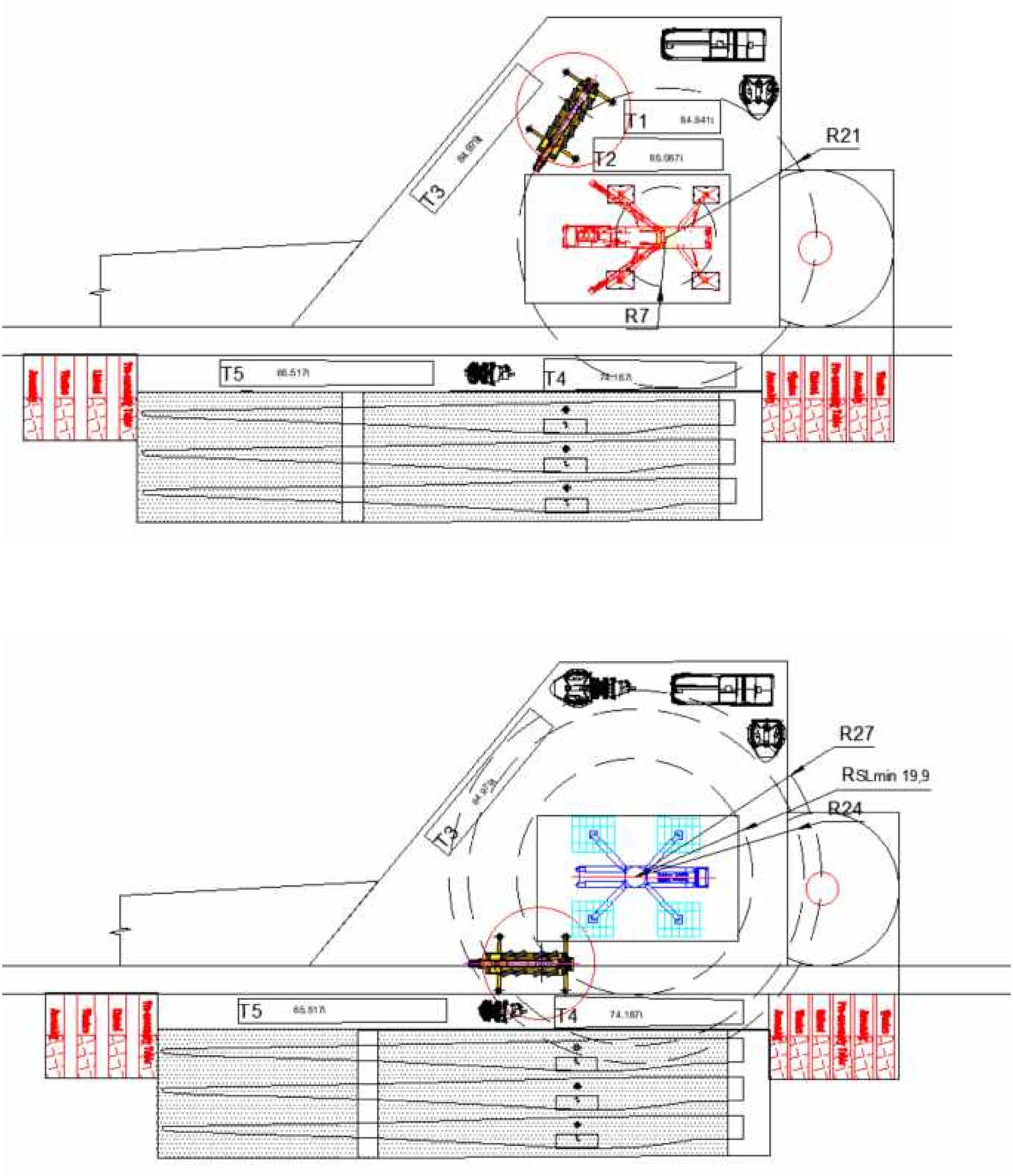


Figure 19 Model T115m – Partial storage assembling with strategy 3 in 2 phases

5.5.6. T115m tubular steel tower Hardstand with strategy 4

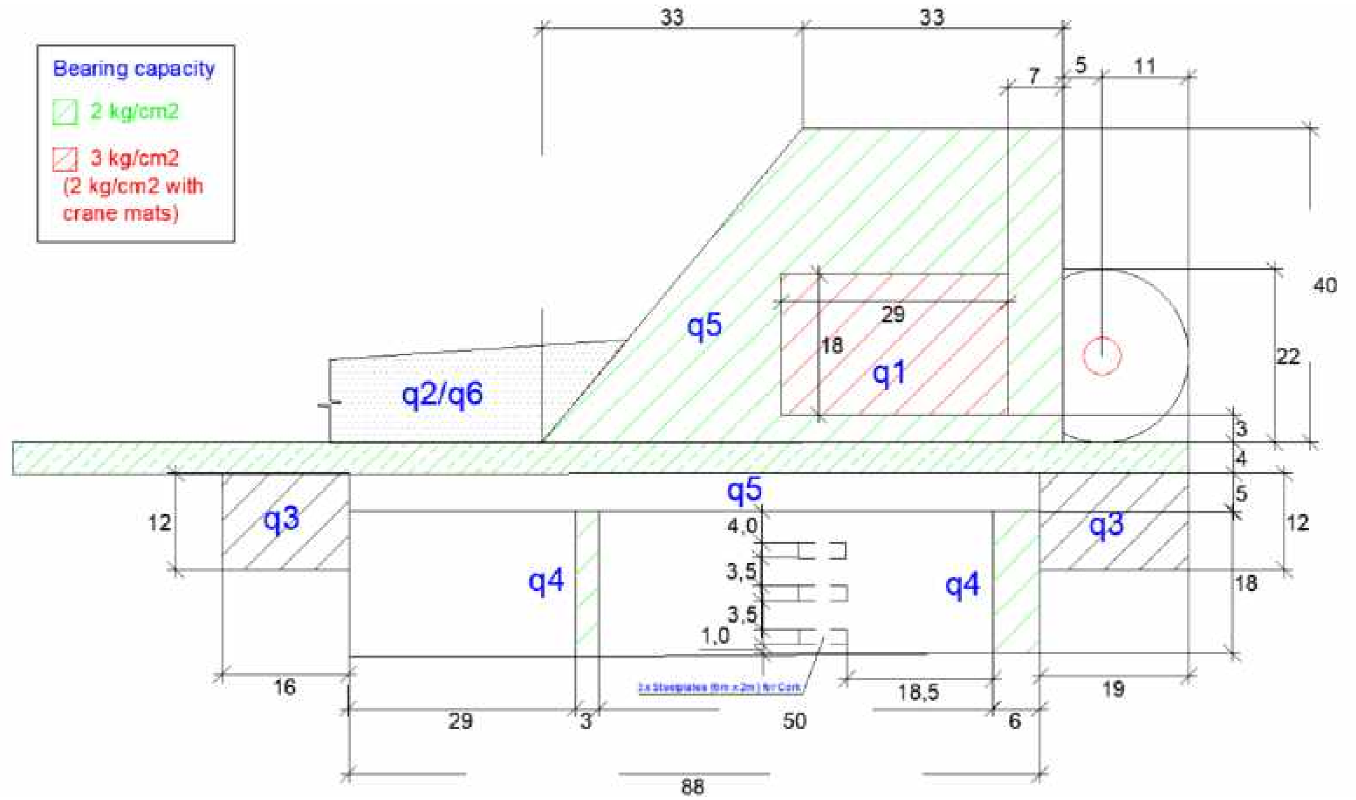
- Tailing crane offloading T115m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 33m x 40m + (33m x 40m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 30m x 38m + (31m x 38m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 32. Dimensions of the areas of model T115m with strategy 4 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly strategy in 1 phase



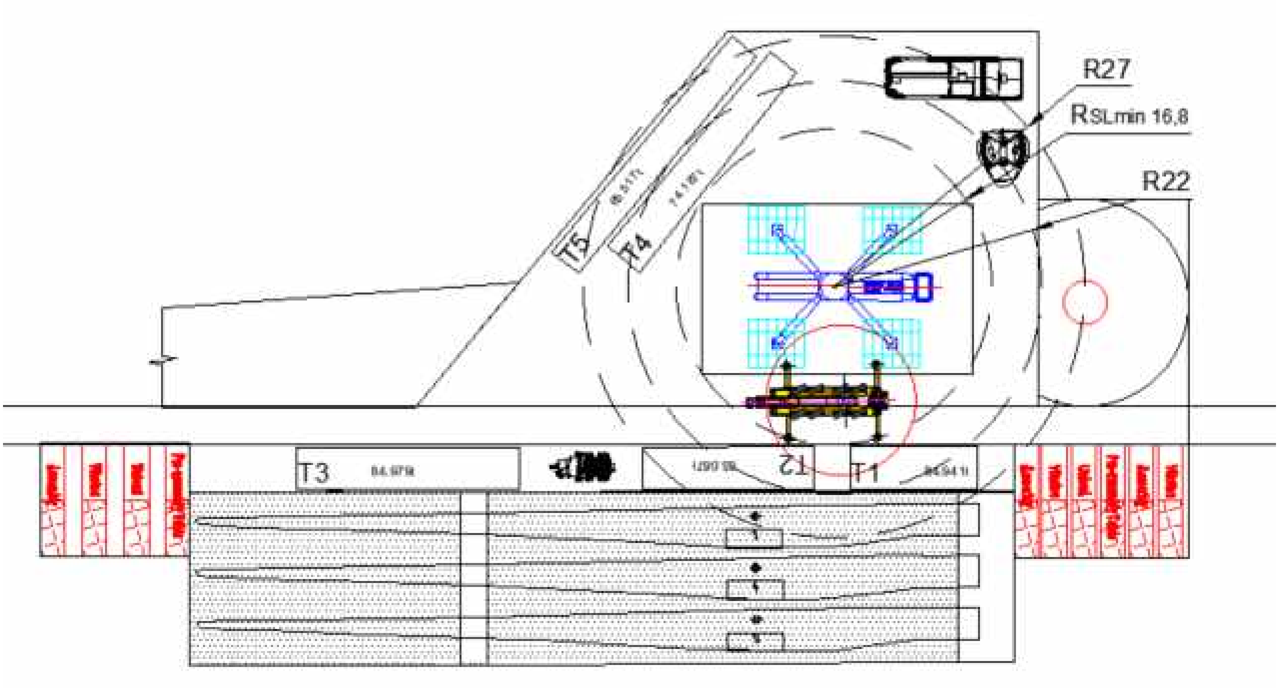
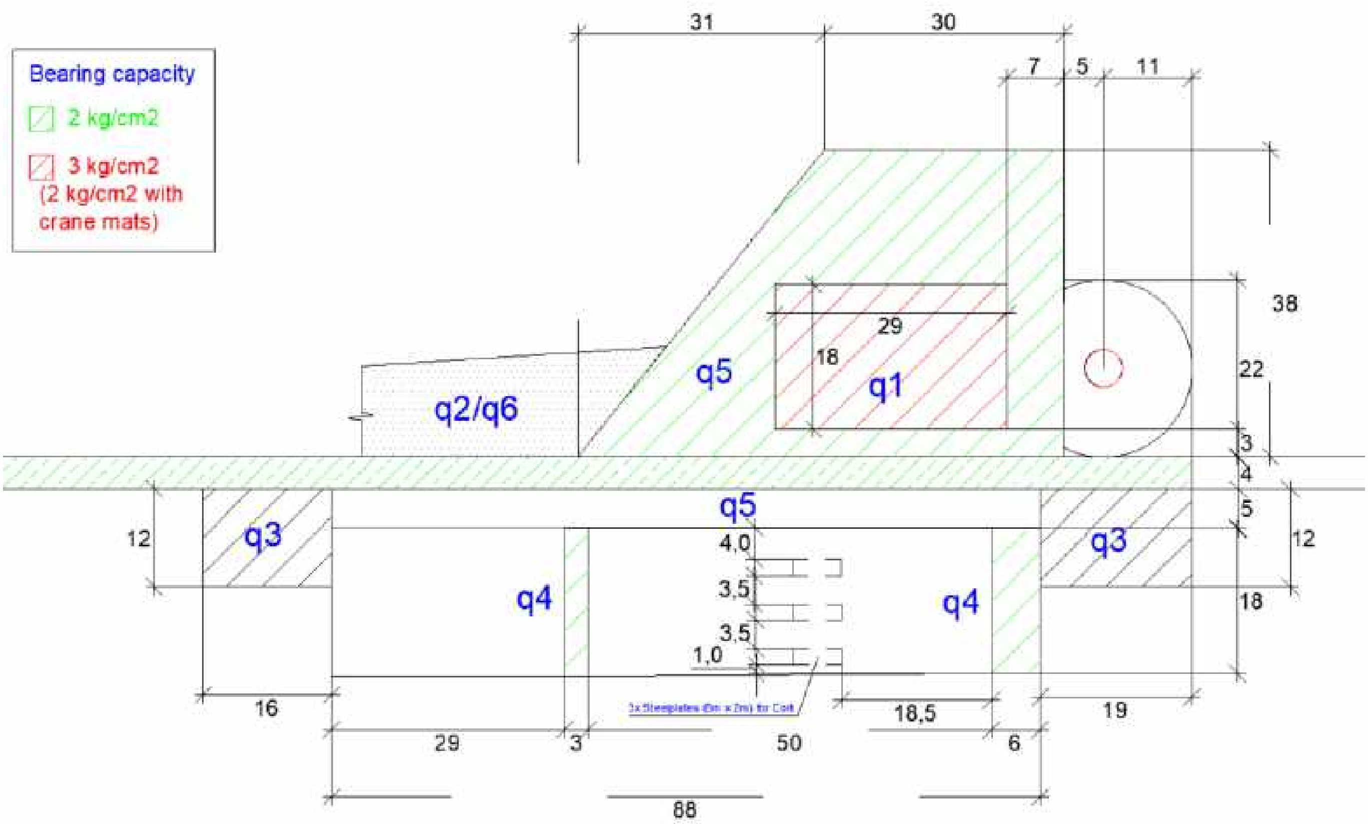


Figure 20 Model T115m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



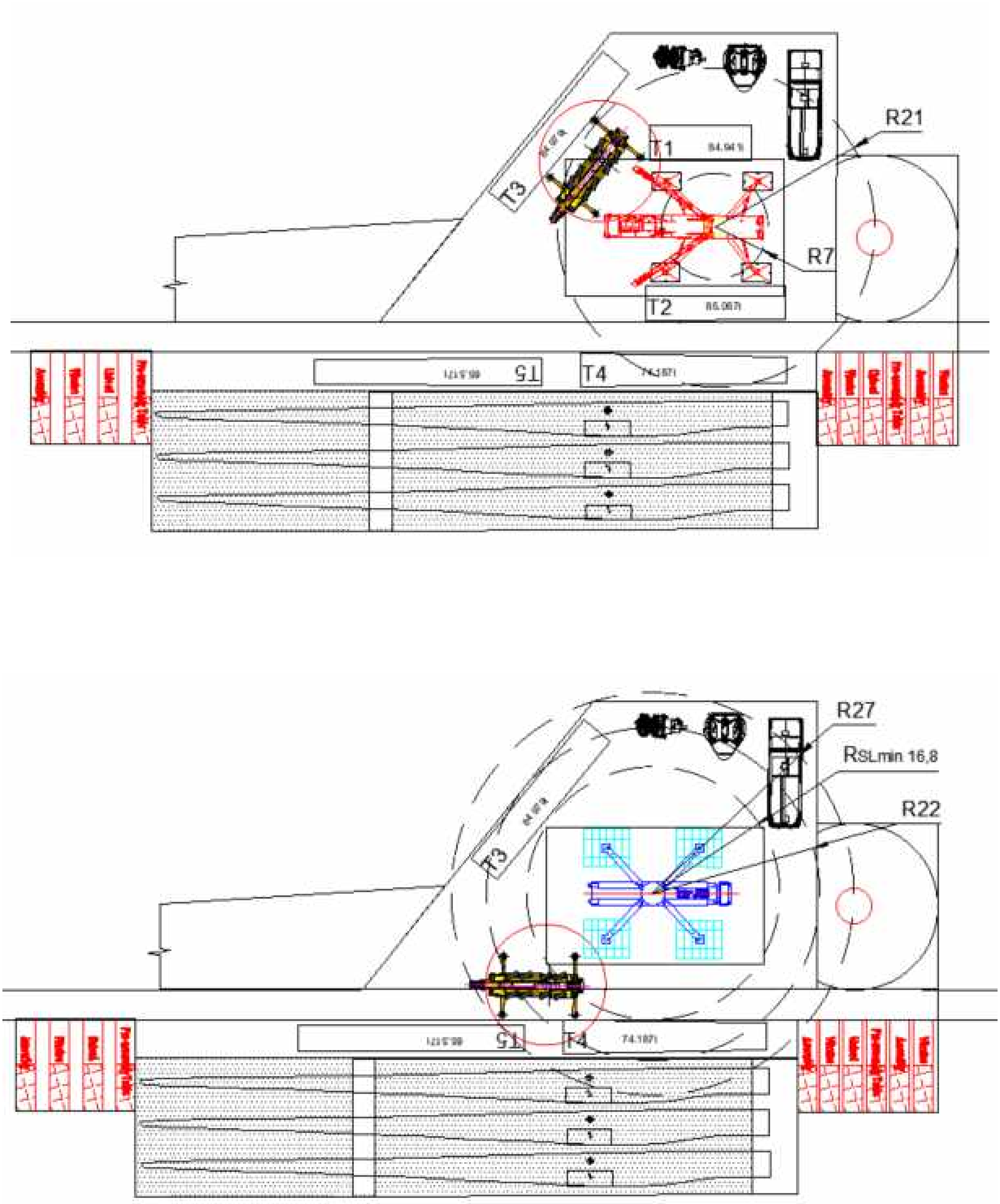


Figure 21 Model T115m – Partial storage assembling with strategy 4 in 2 phases

5.5.7. T135m (52A) tubular steel tower Hardstand with strategy 3

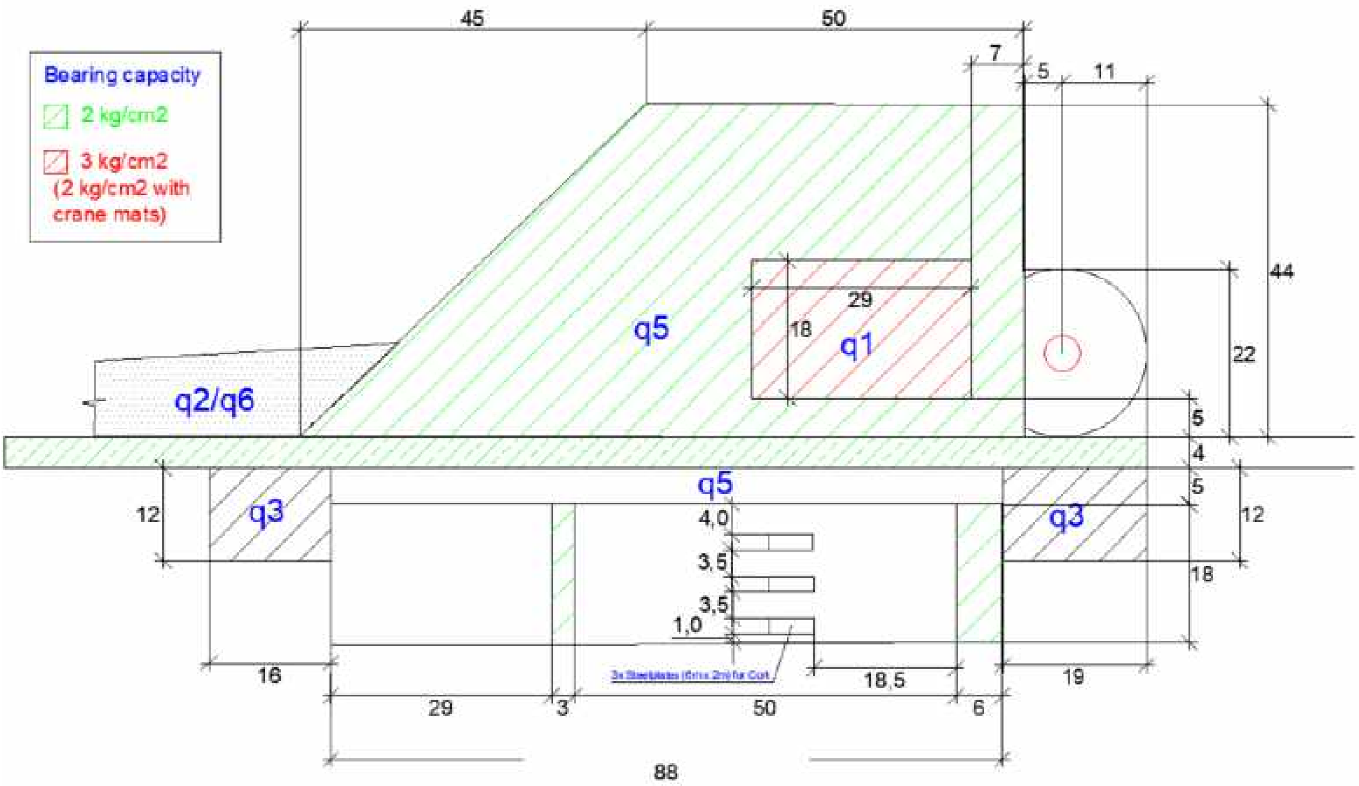
- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6 dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 33. Dimensions of the areas of model T135m (52A) with strategy 3 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1 phase – STD tower



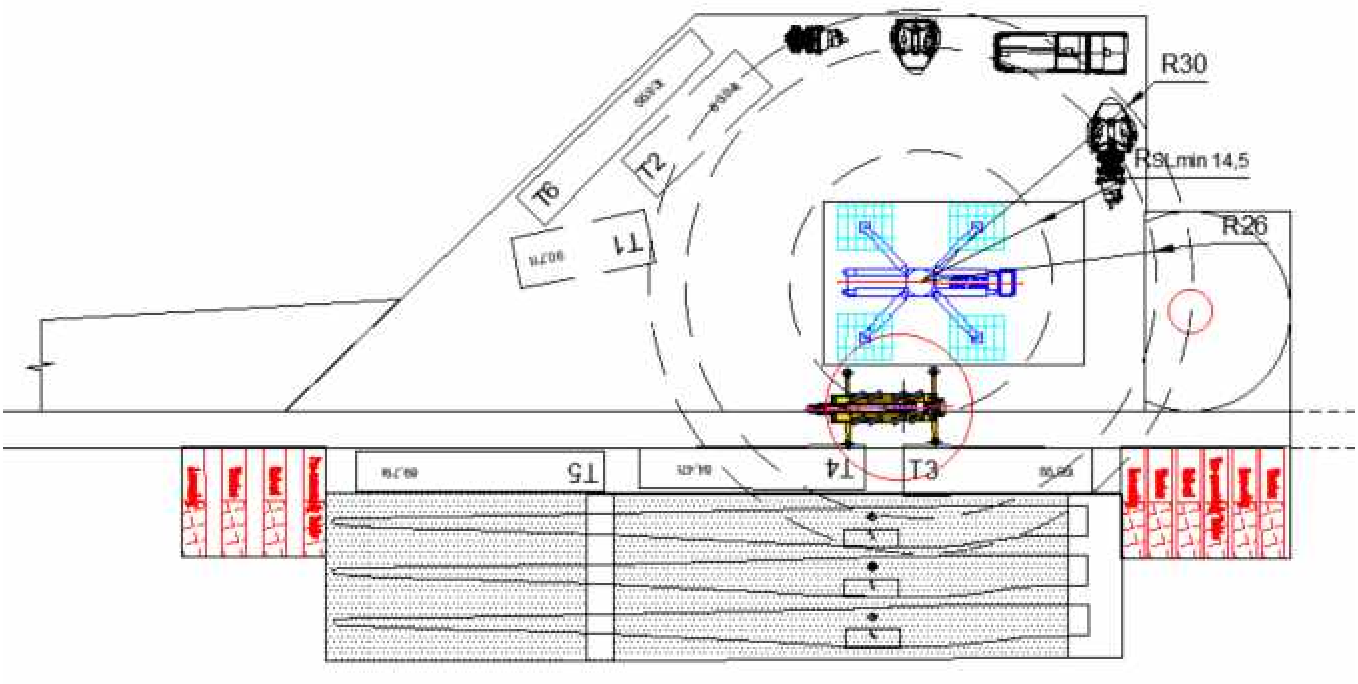
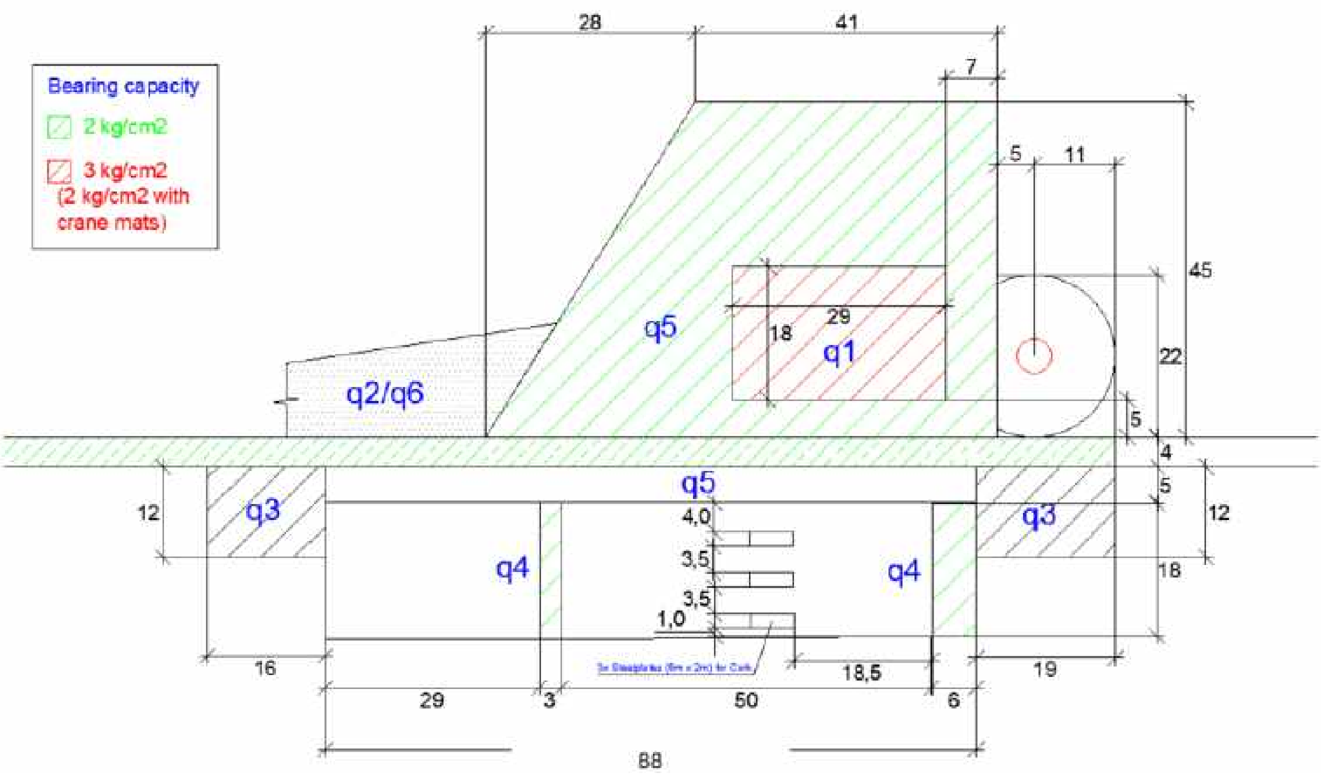


Figure 22. Model T135m (52A) – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



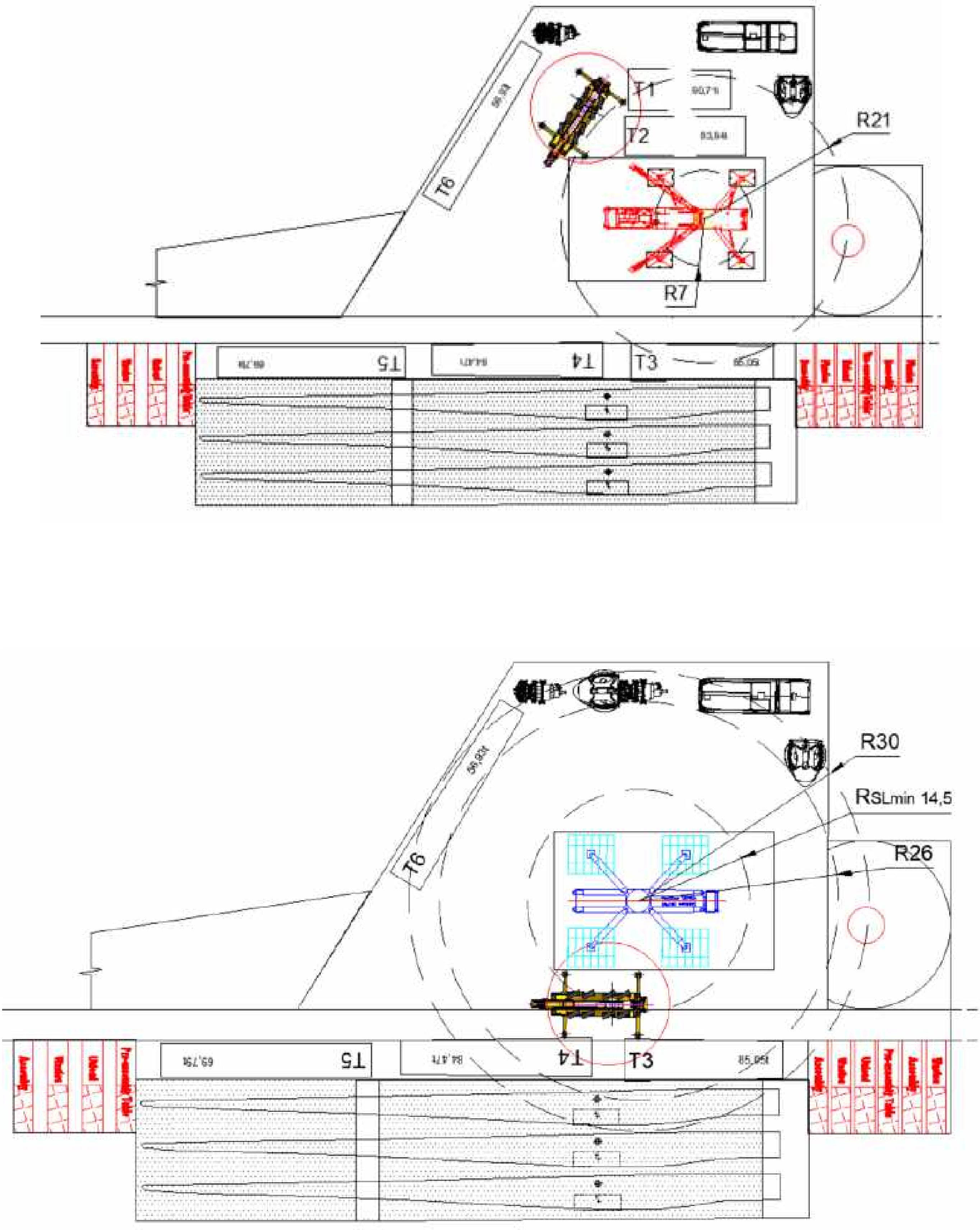


Figure 23. Model T135m (52A) - Partial storage assembling with strategy 3 in 2 phases

5.5.8. T135m (52A) tubular steel tower Hardstand with strategy 4

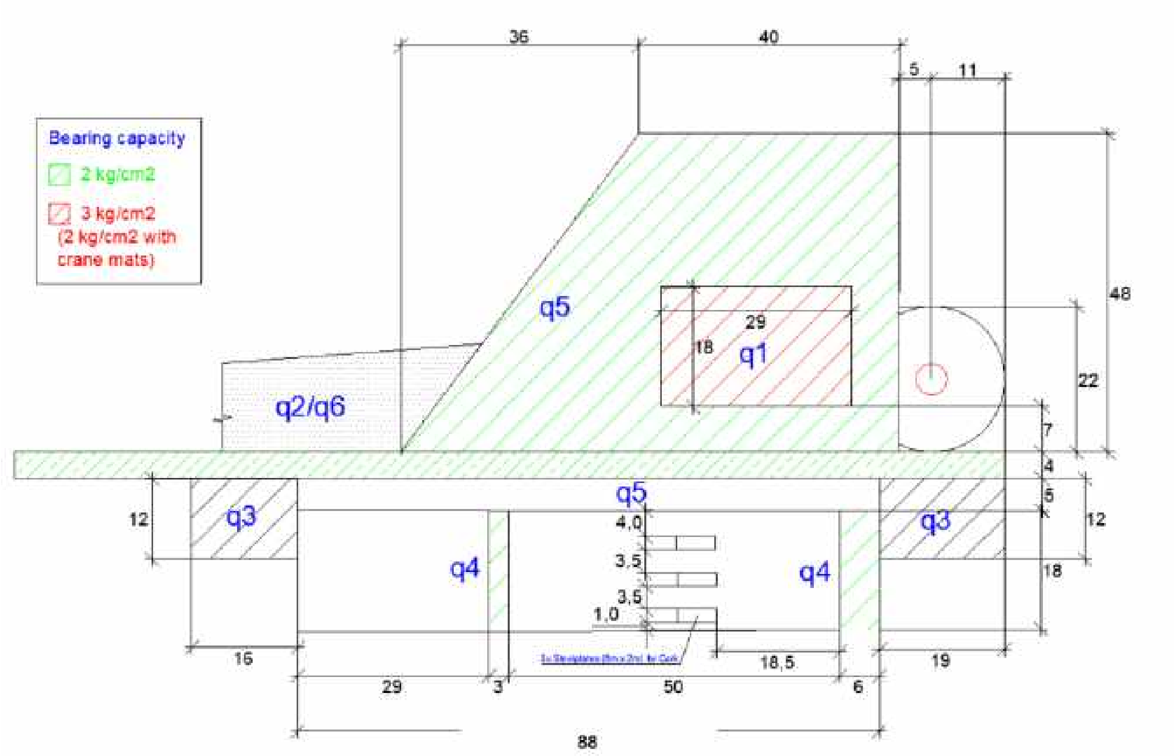
- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 40m x 48m + (36m x 48m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 32m x 48m + (36m x 48m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 34. Dimensions of the areas of model T135m (52A) with strategy 4 – Tailing crane offloading

- Total storage – Assembly in 1 phase



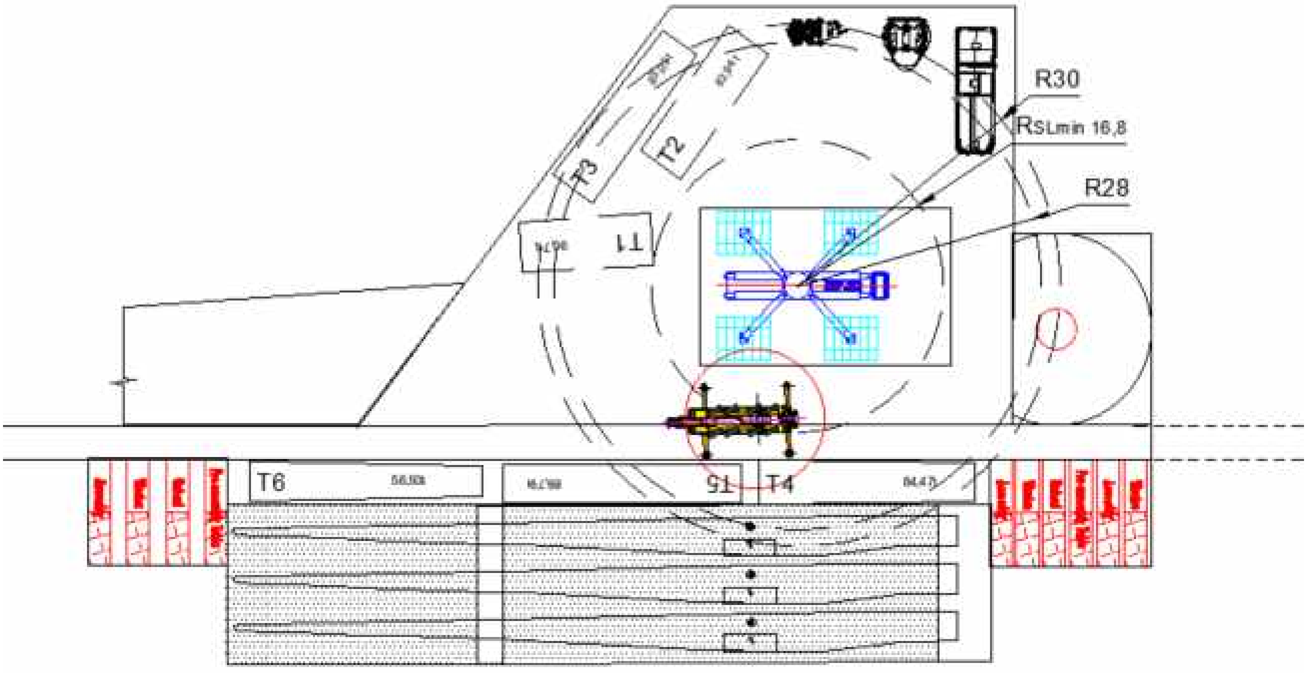
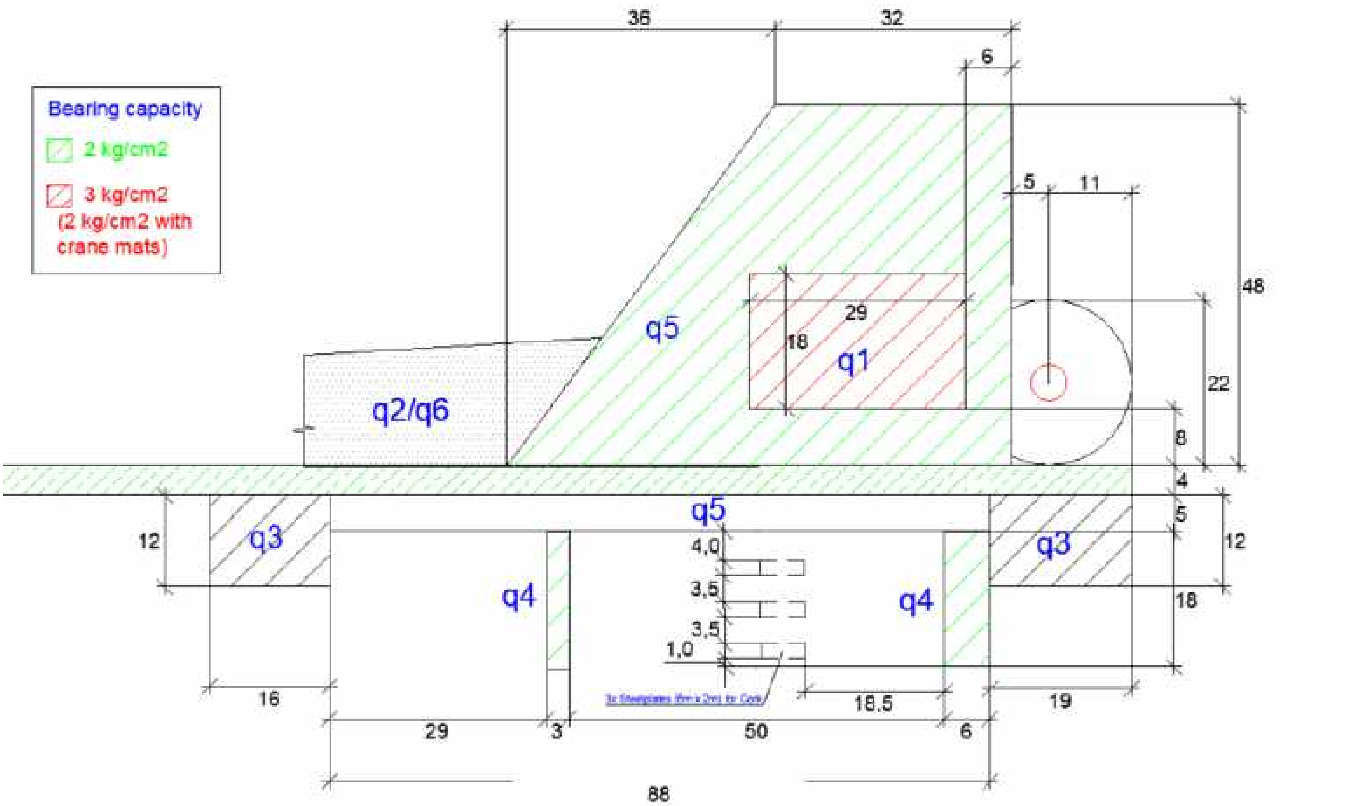


Figure 24. Model T135m (52A) – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



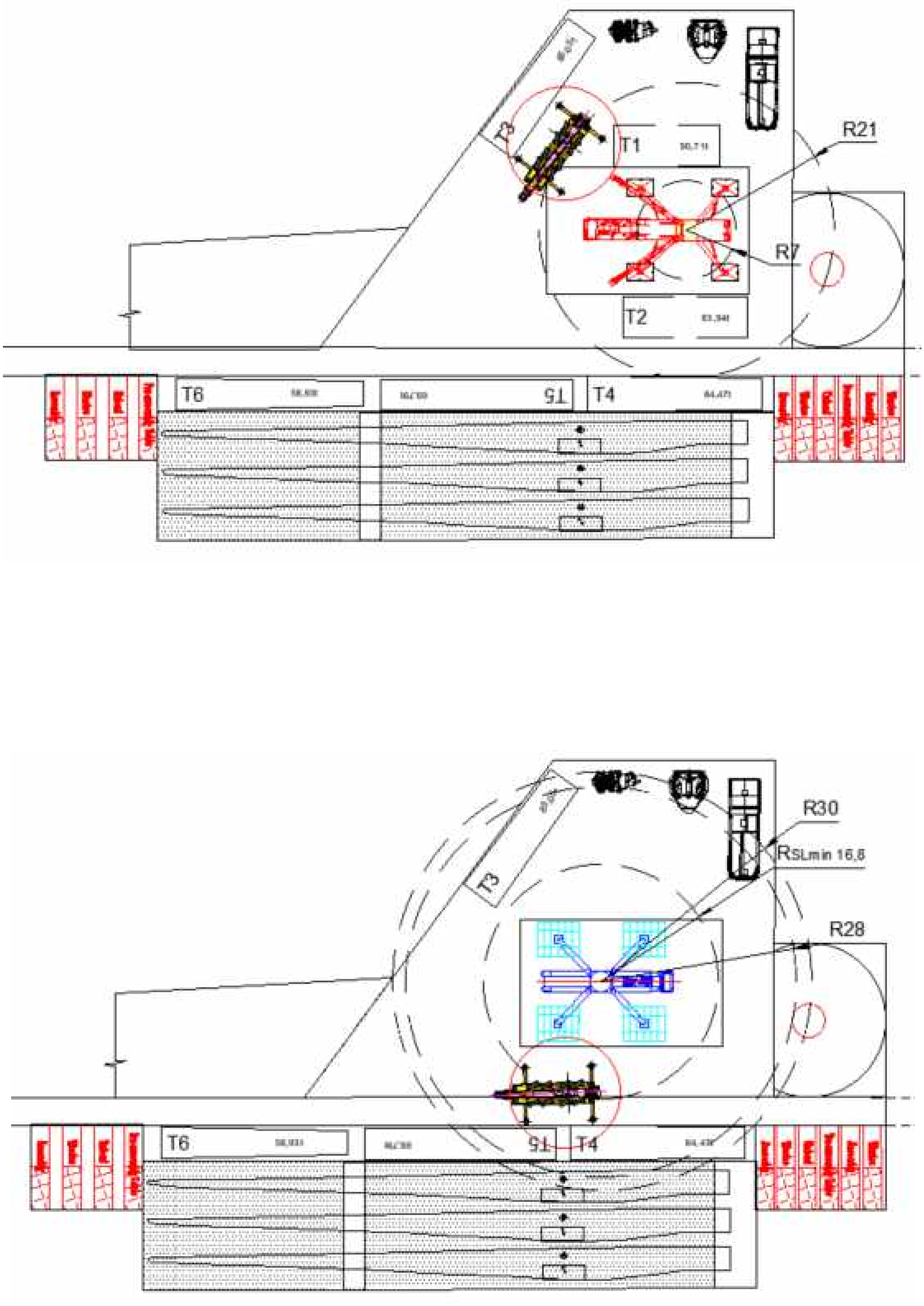


Figure 25. Model T135m (52A) - Partial storage assembling with strategy 4 in 2 phases

5.5.9. T135m (54A) tubular steel tower Hardstand with strategy 3

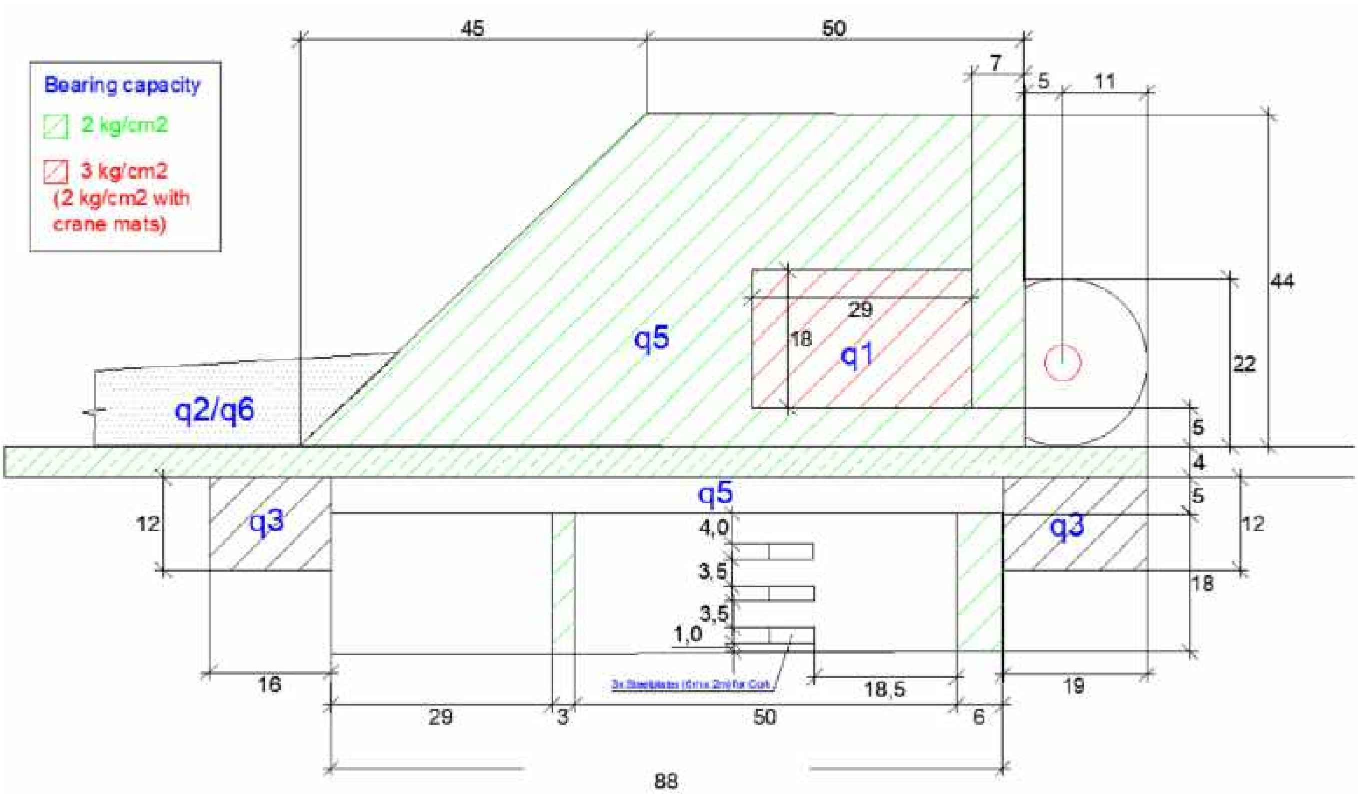
- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 35. Dimensions of the areas of model T135m (54A) with strategy 3 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



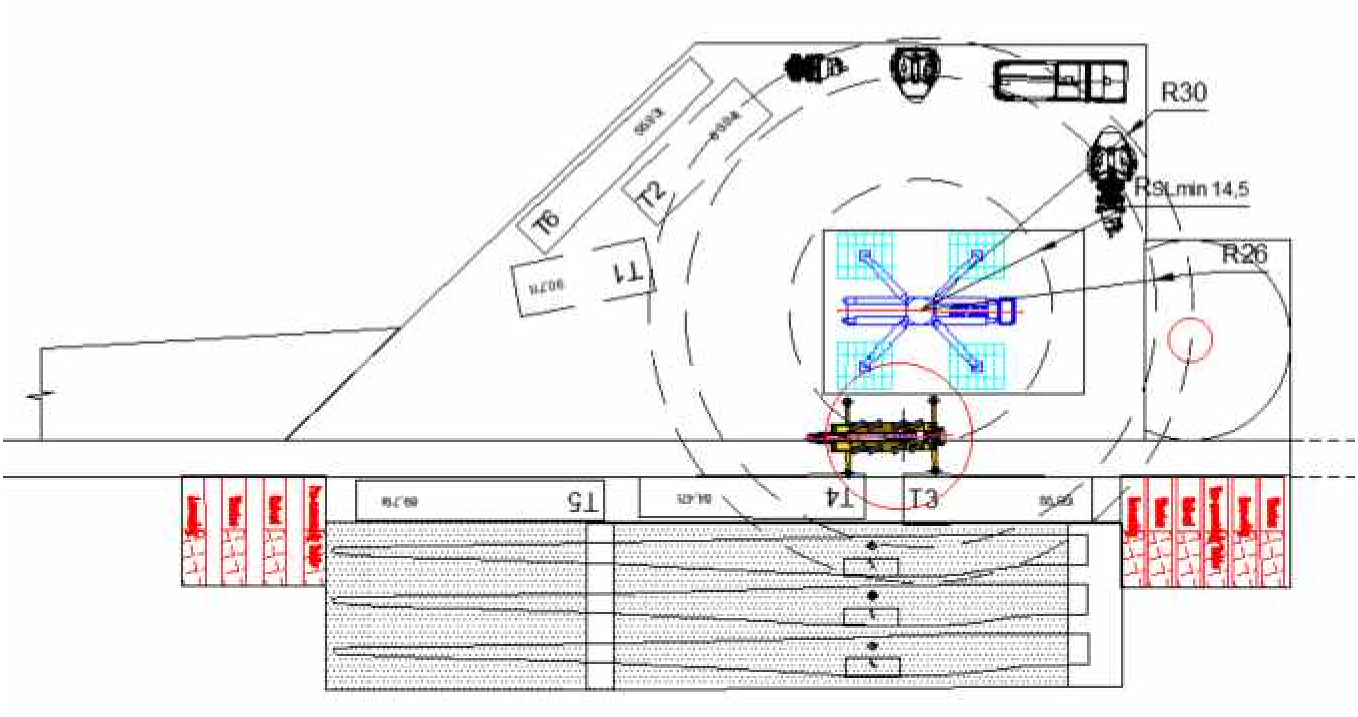
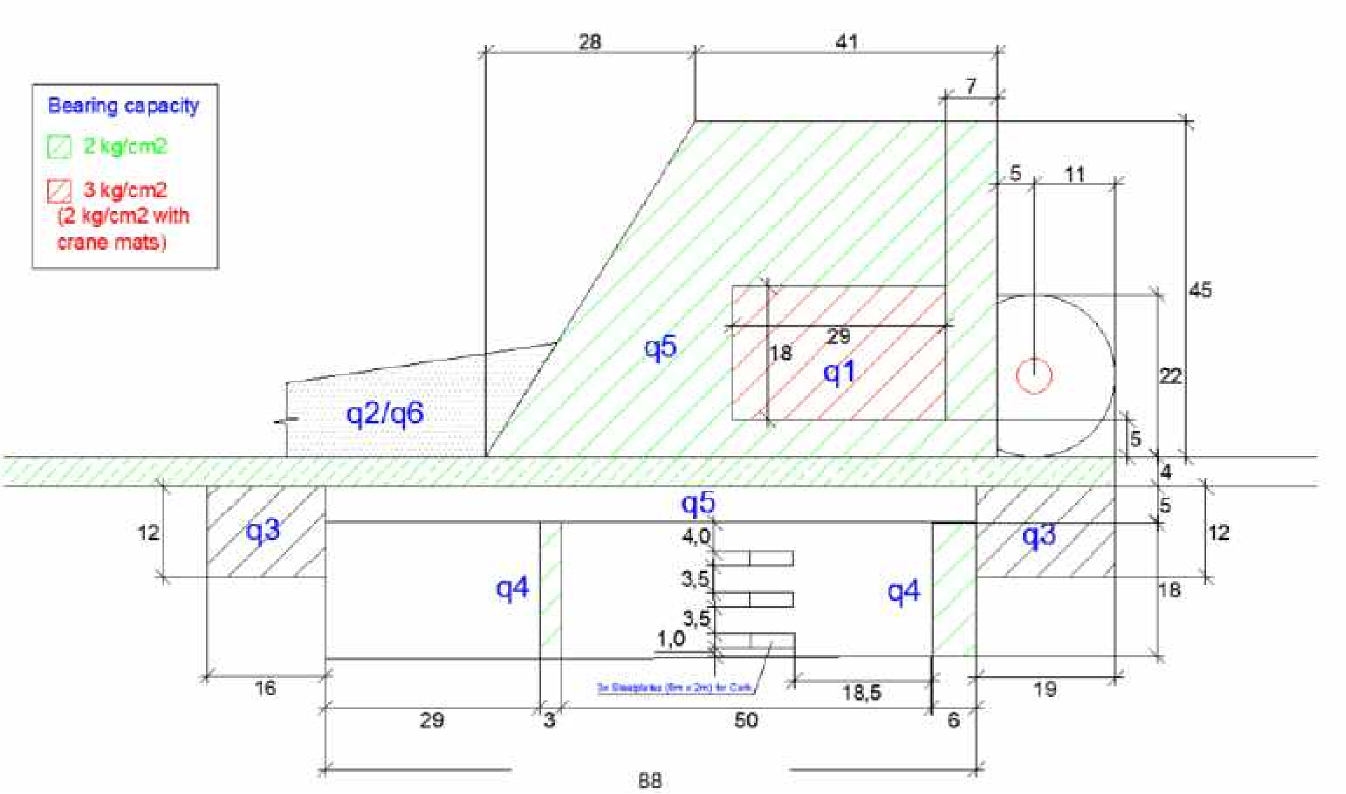
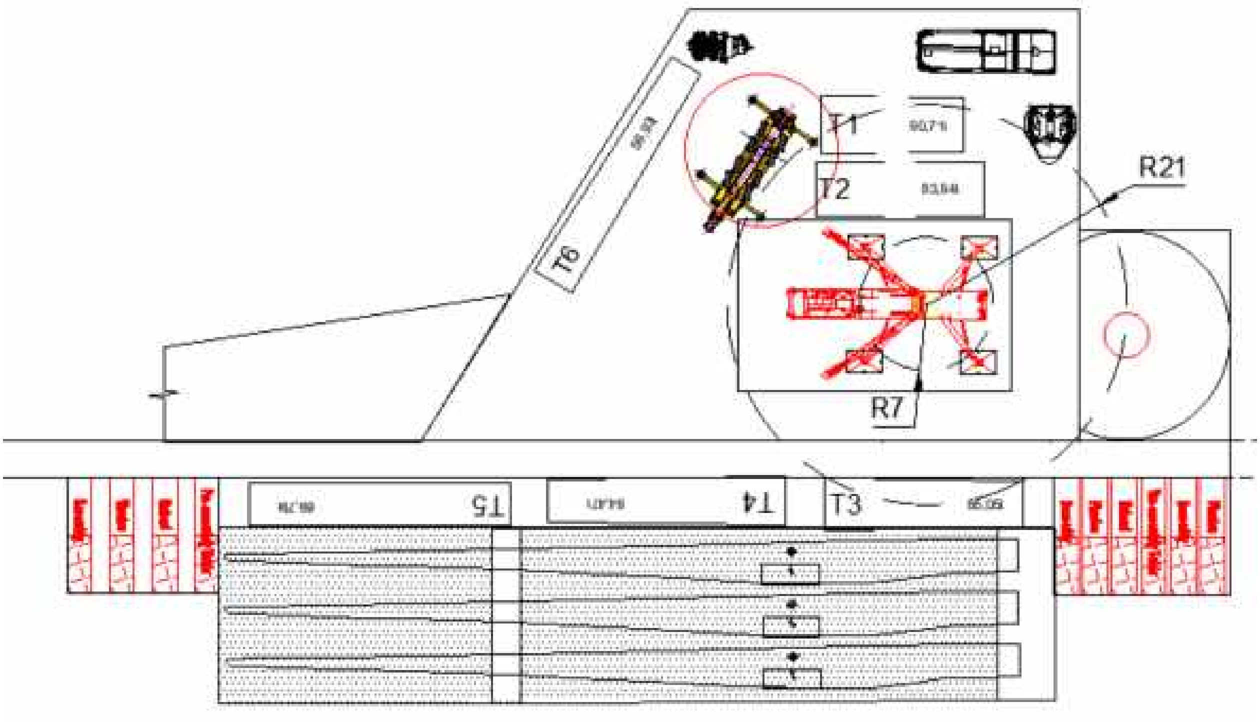


Figure 26. Model T135m (54A) – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower





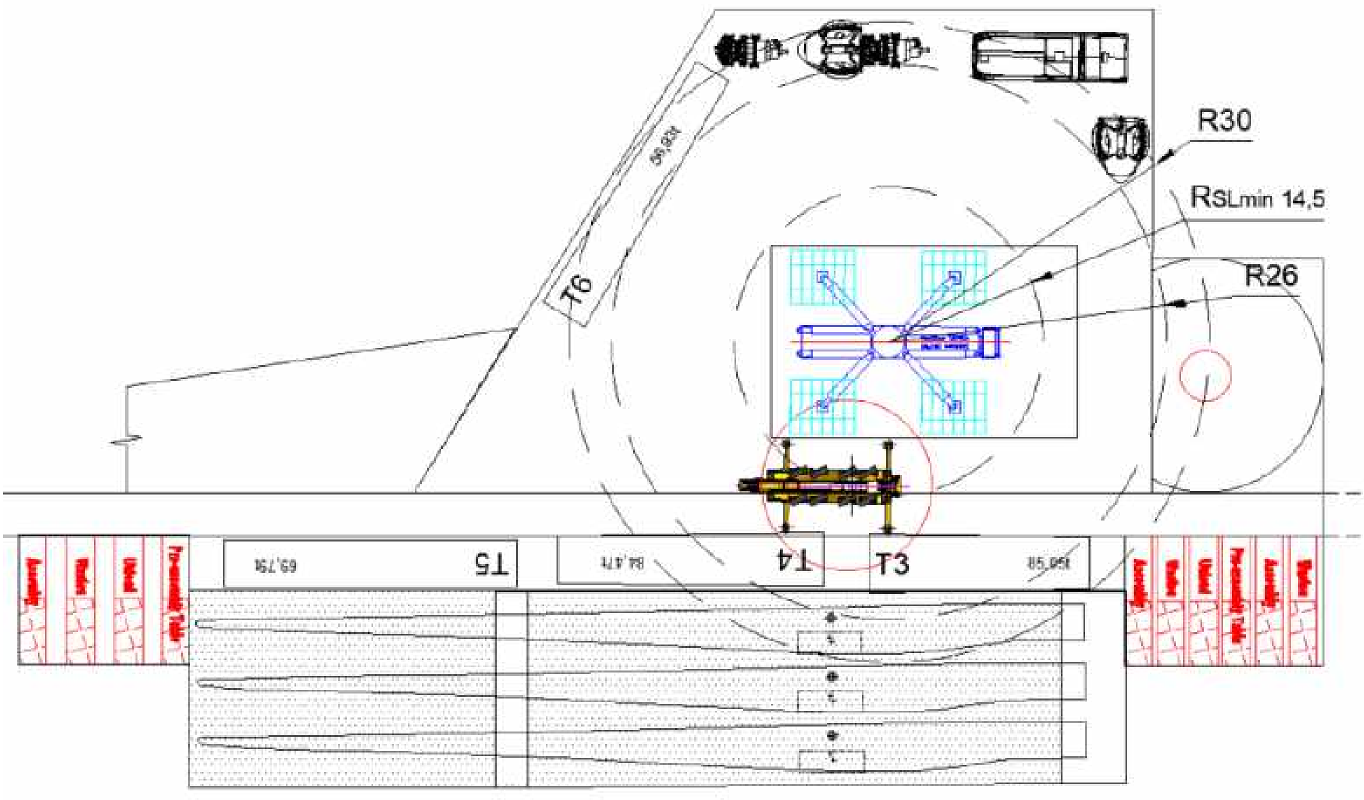


Figure 27. Model T135m (54A) -.Partial storage assembling with strategy 3 in 2 phases

5.5.10. T135m (54A) tubular steel tower Hardstand with strategy 4

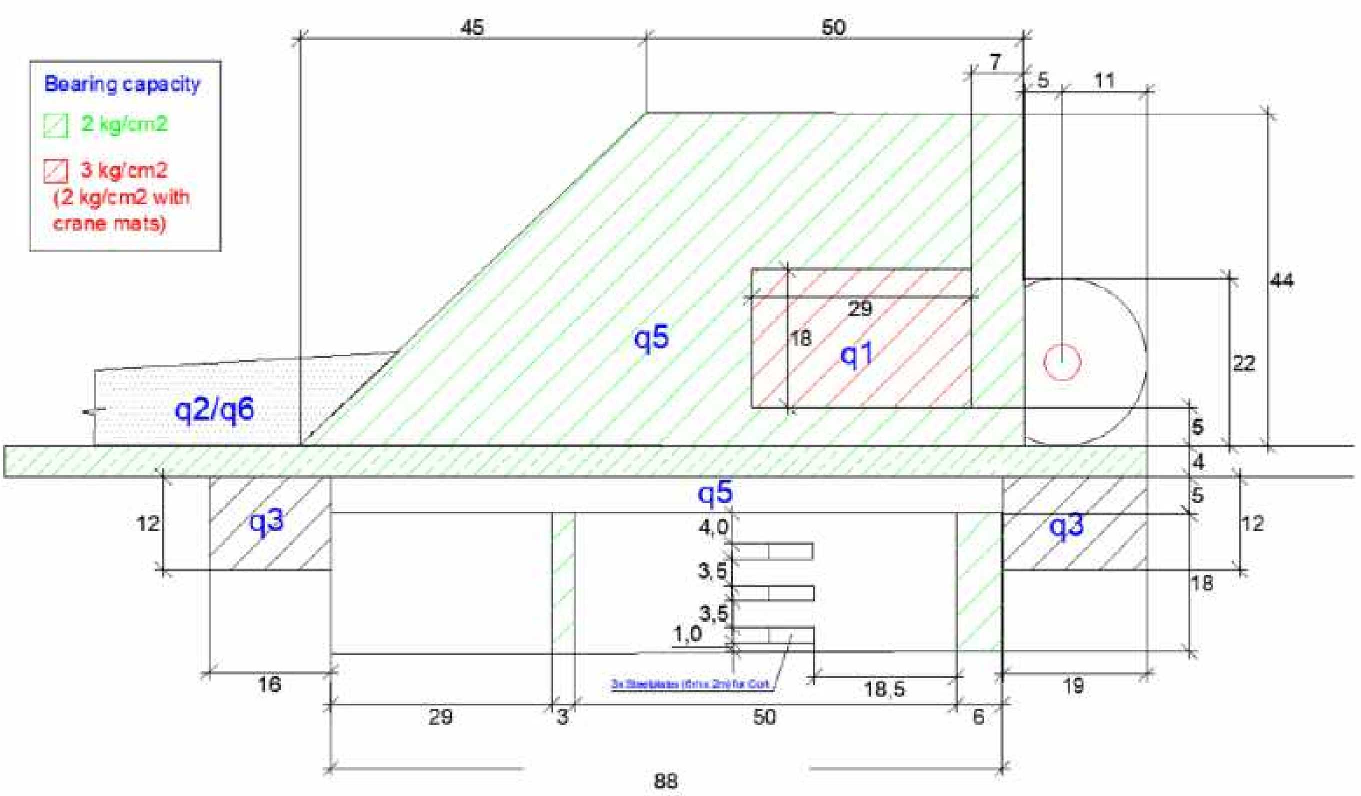
- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 36. Dimensions of the areas of model T135m (54A) with strategy 4 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



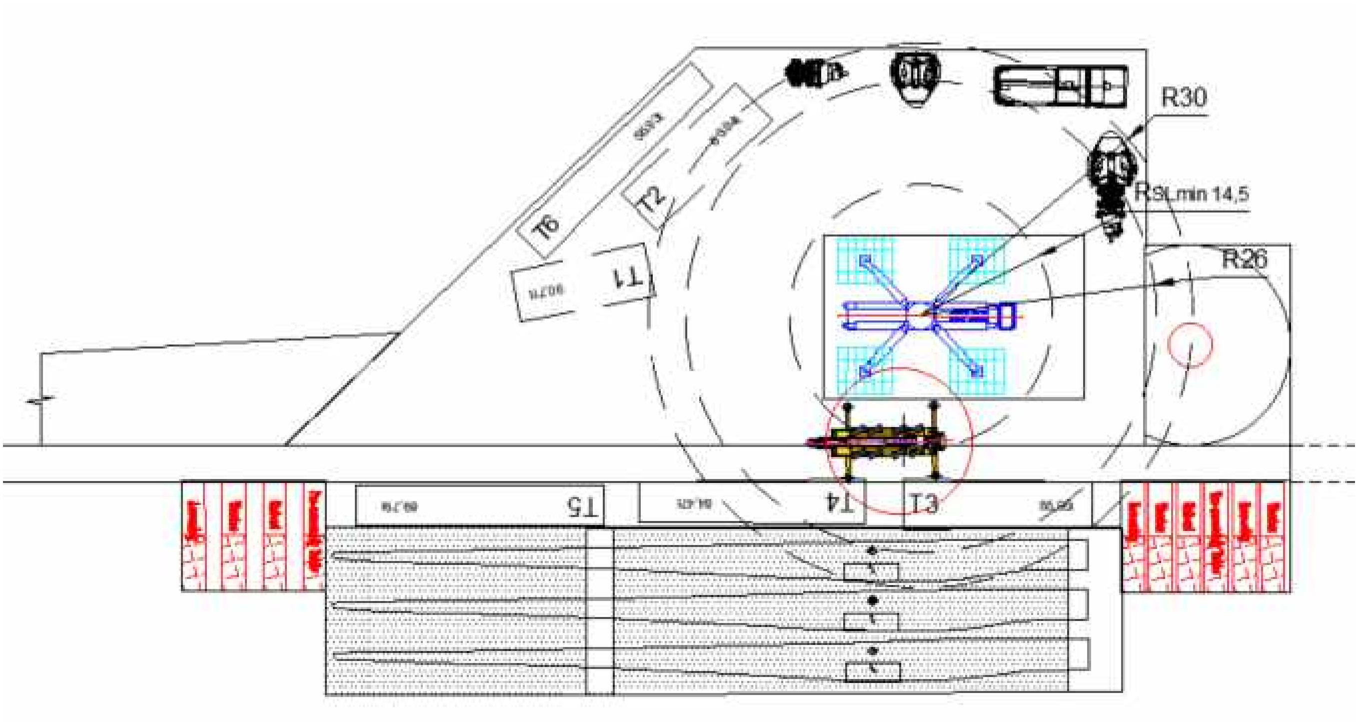
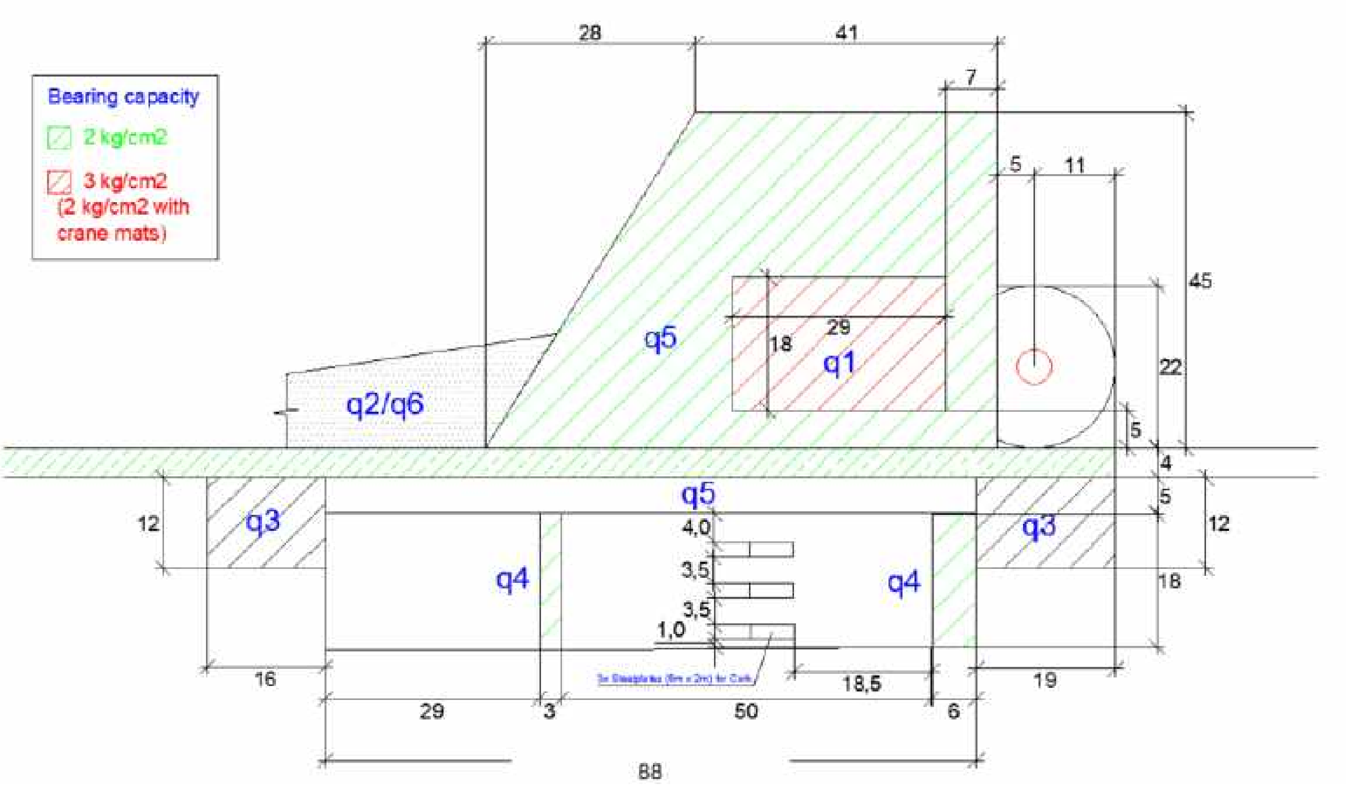


Figure 28. Model T135m (54A) – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



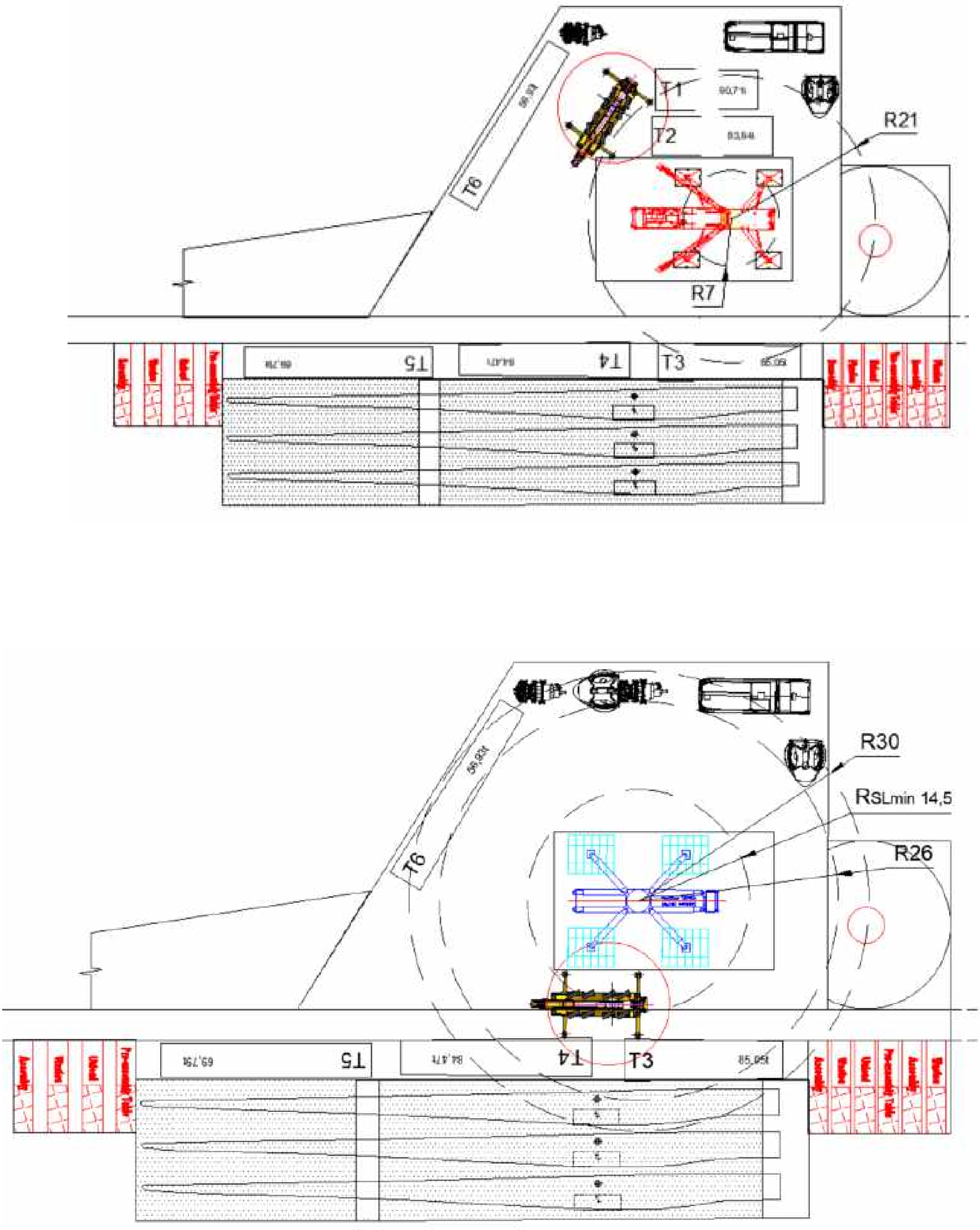


Figure 29. Model T135m (54A) -.Partial storage assembling with strategy 4 in 2 phases

5.5.11. T145m andT150m tubular steel tower Hardstand with strategy 3

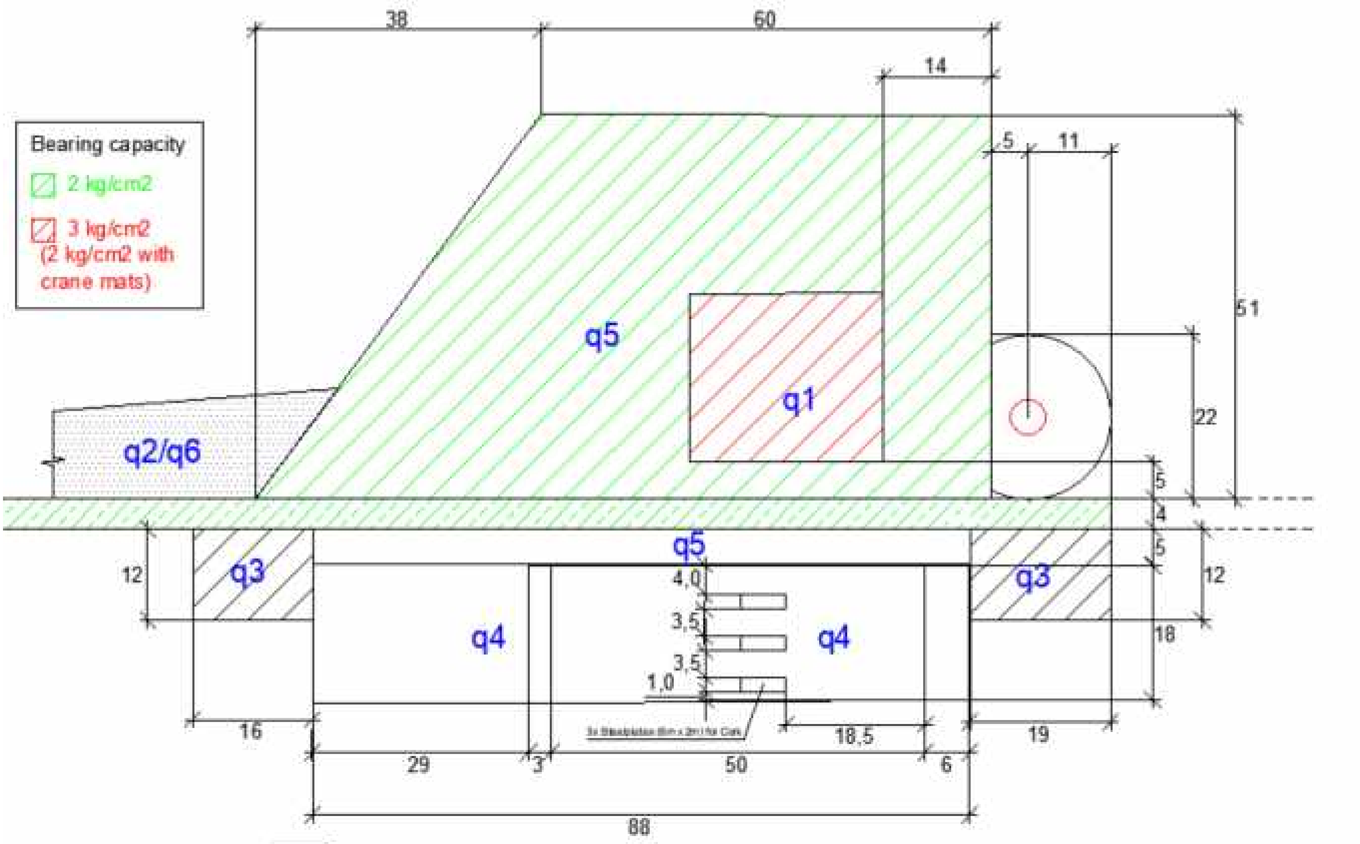
- Tailing crane offloading T145m&T150m

Storage conditions	Width x length
Total Storage	q1: 26m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 60m x 51m + (38m x 51m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 47m x 52m + (44m x 52m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 37. Dimensions of the areas of model T150m with strategy 3 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



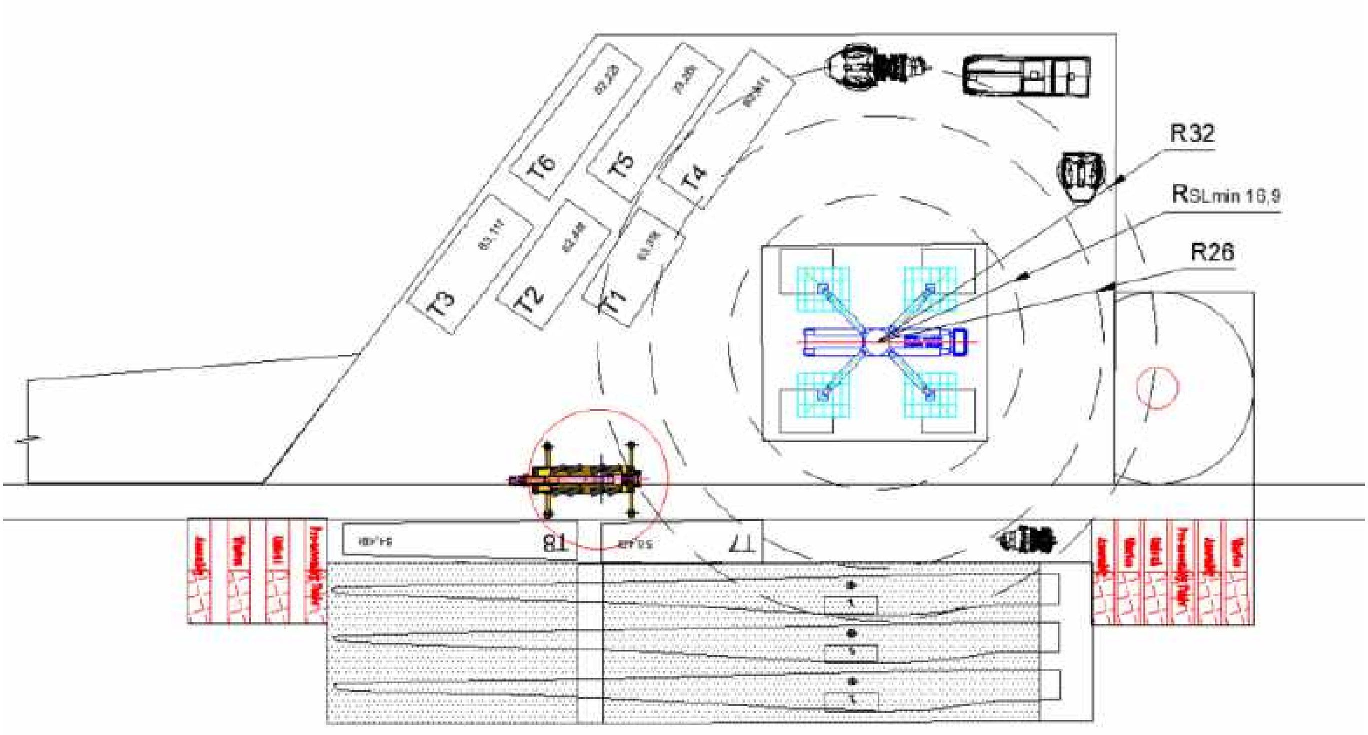
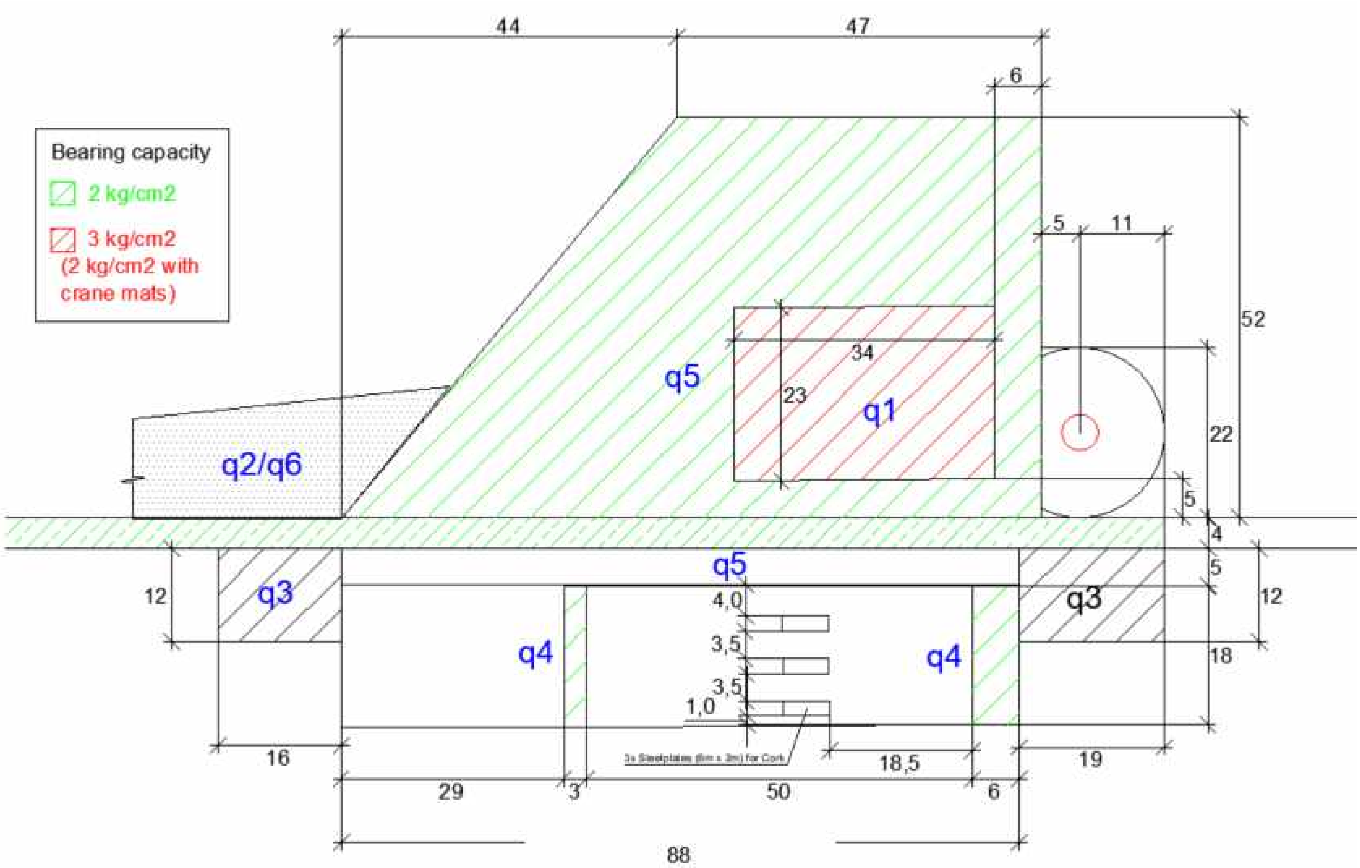


Figure 30. Model T150m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



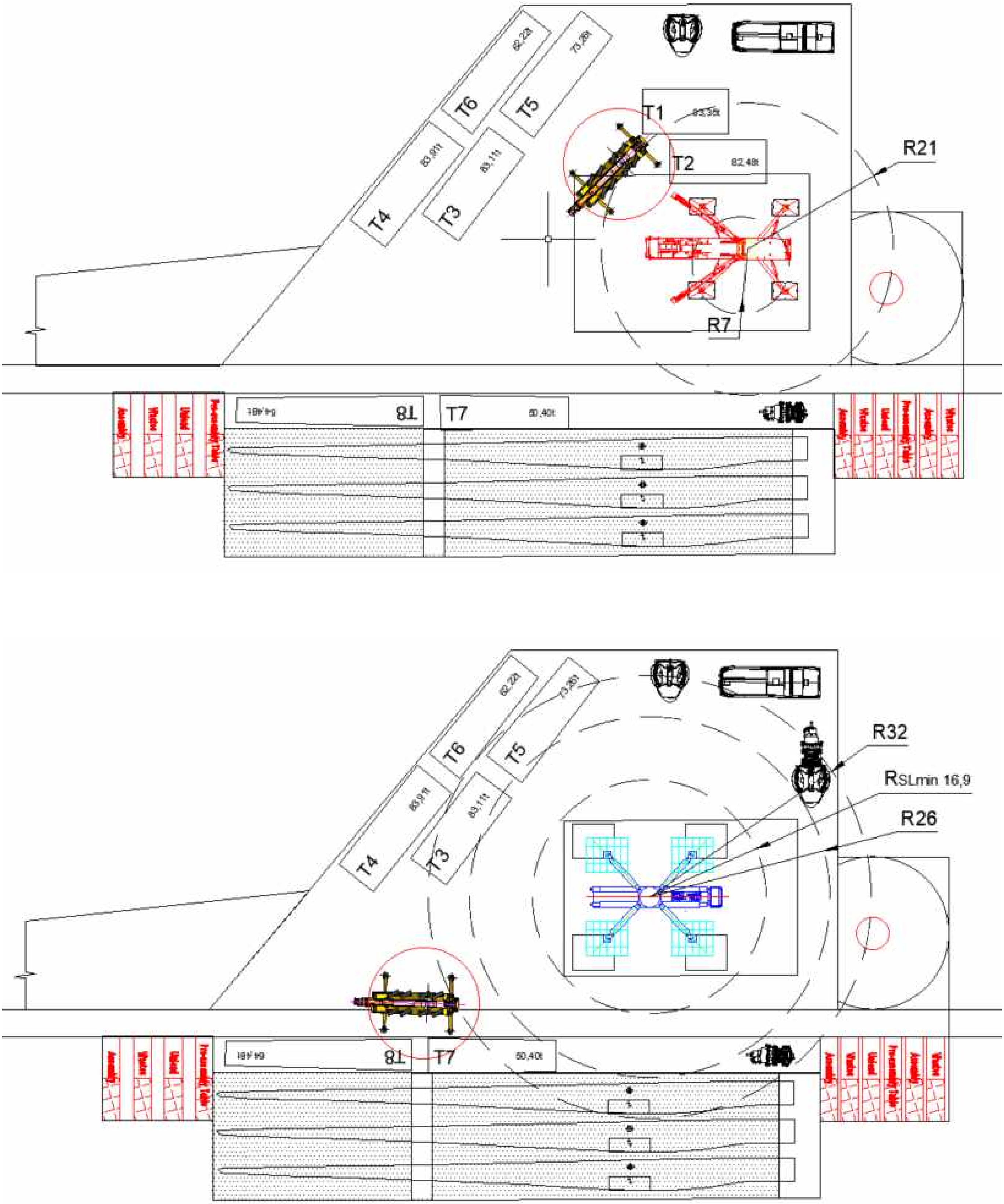


Figure 31. Model T150m - Partial storage assembling with strategy 3 in 2 phases

5.5.12. T145m and T150m tubular steel tower Hardstand with strategy 4

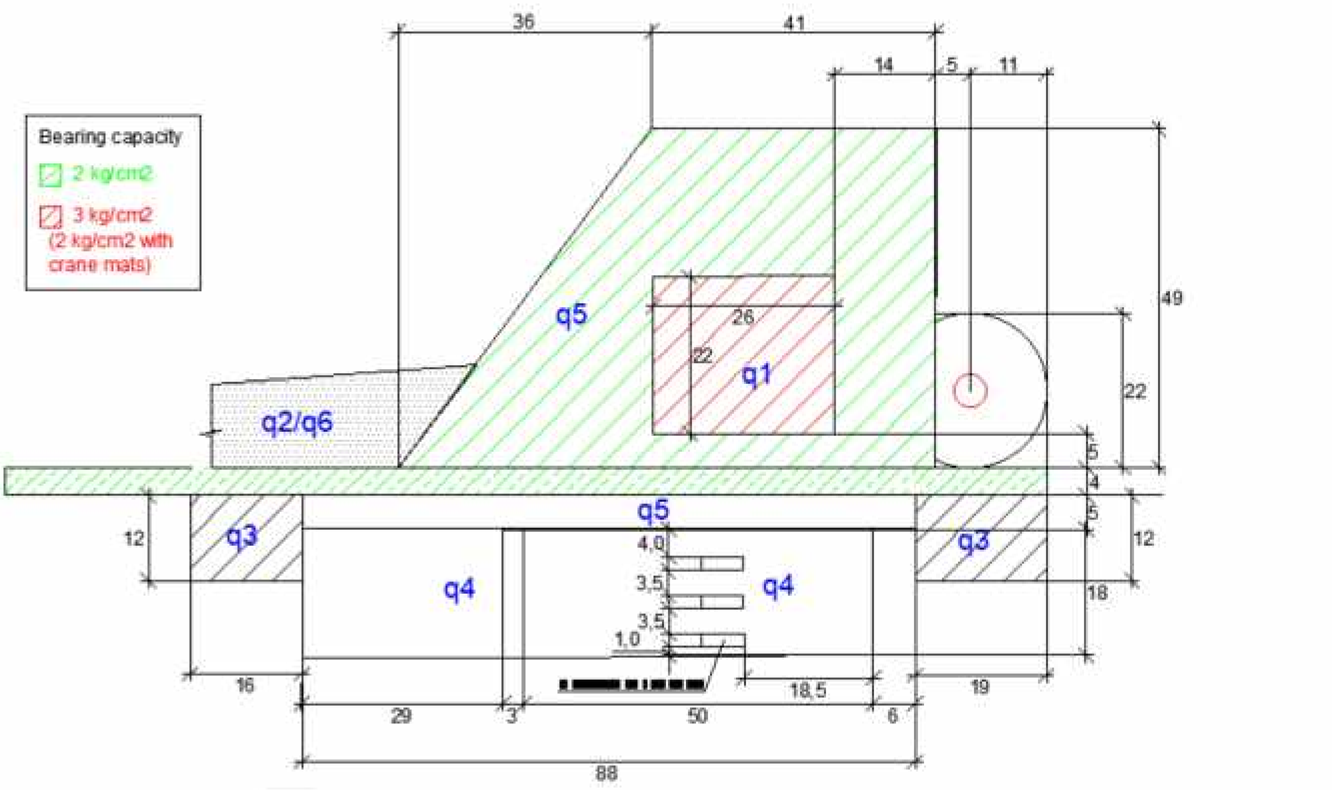
- Tailing crane offloading T145m&T150m

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 39m x 49m + (41m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 38. Dimensions of the areas of model T150m with strategy 4 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



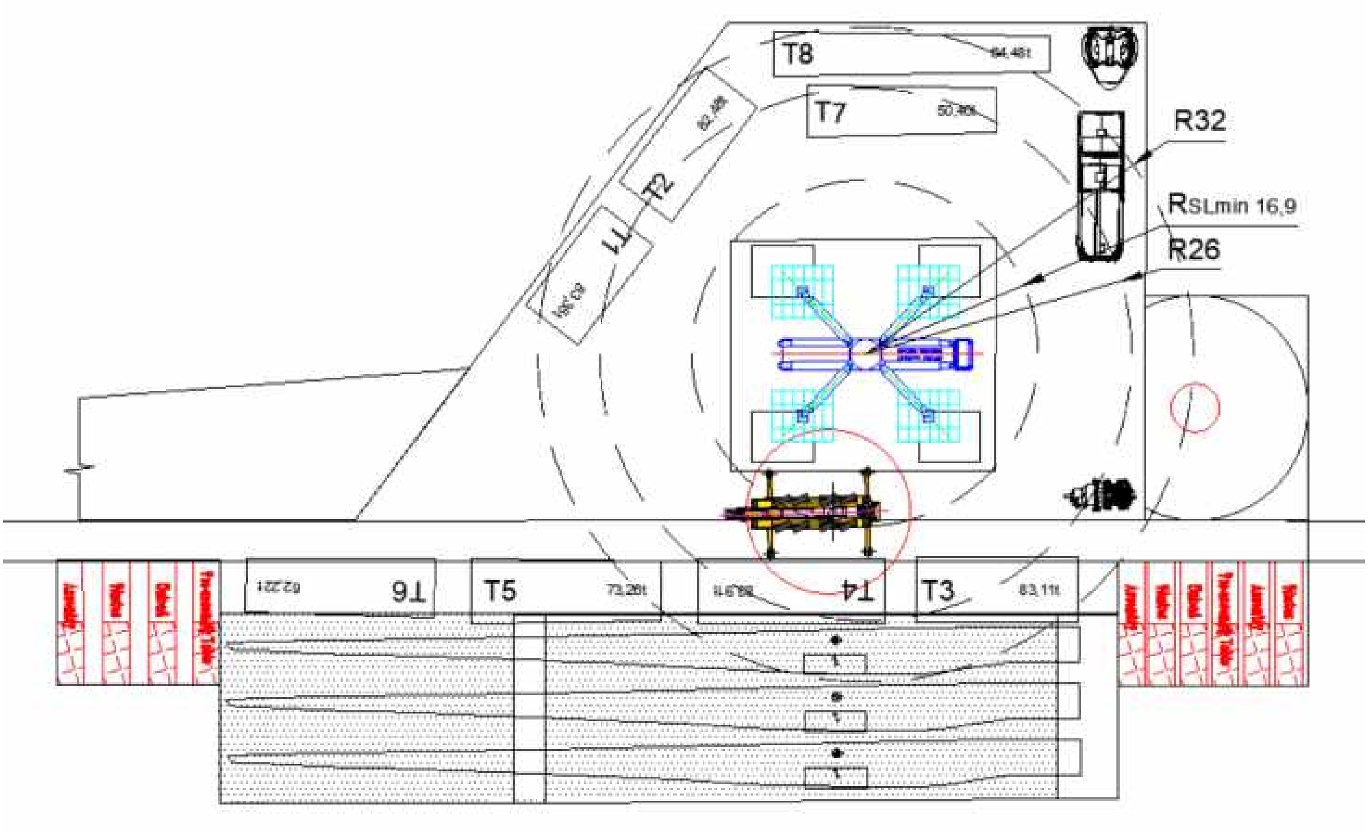
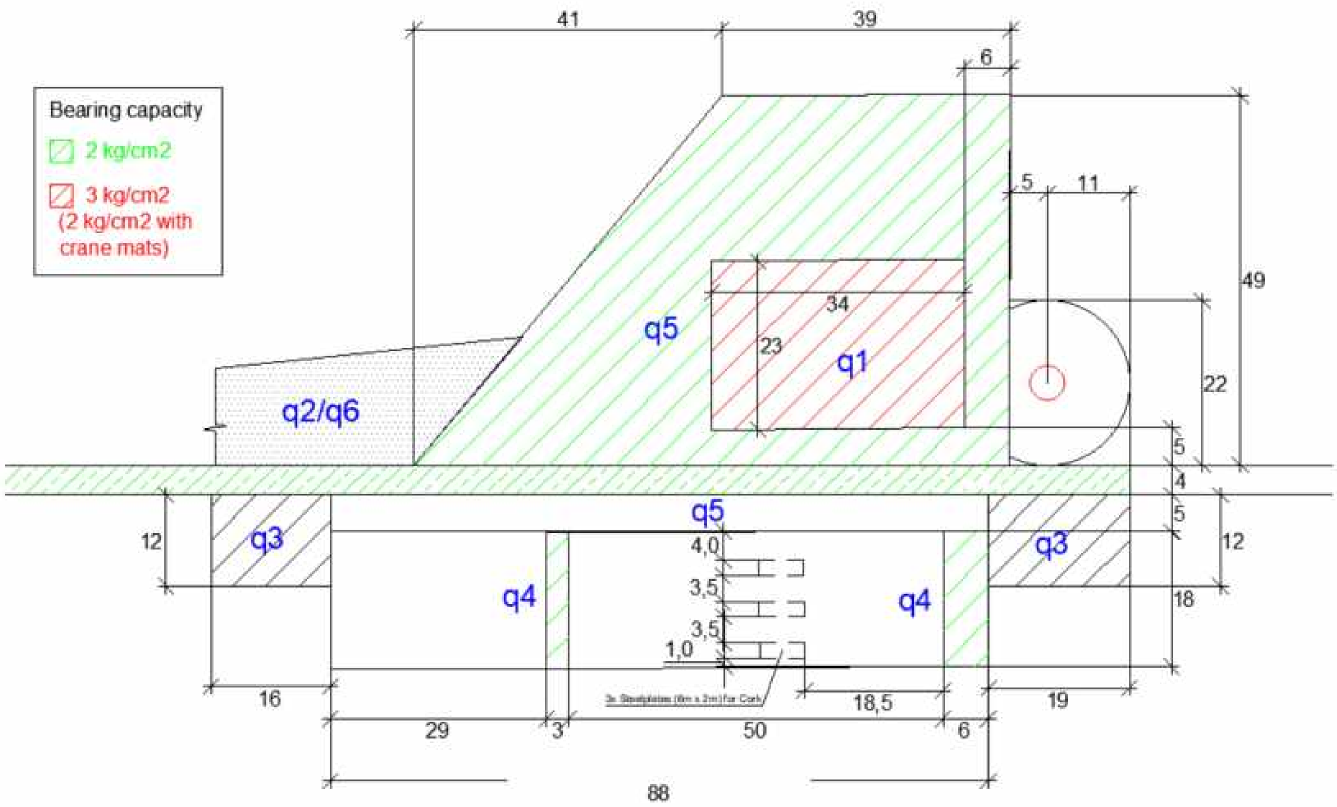


Figure 32. Model T150m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



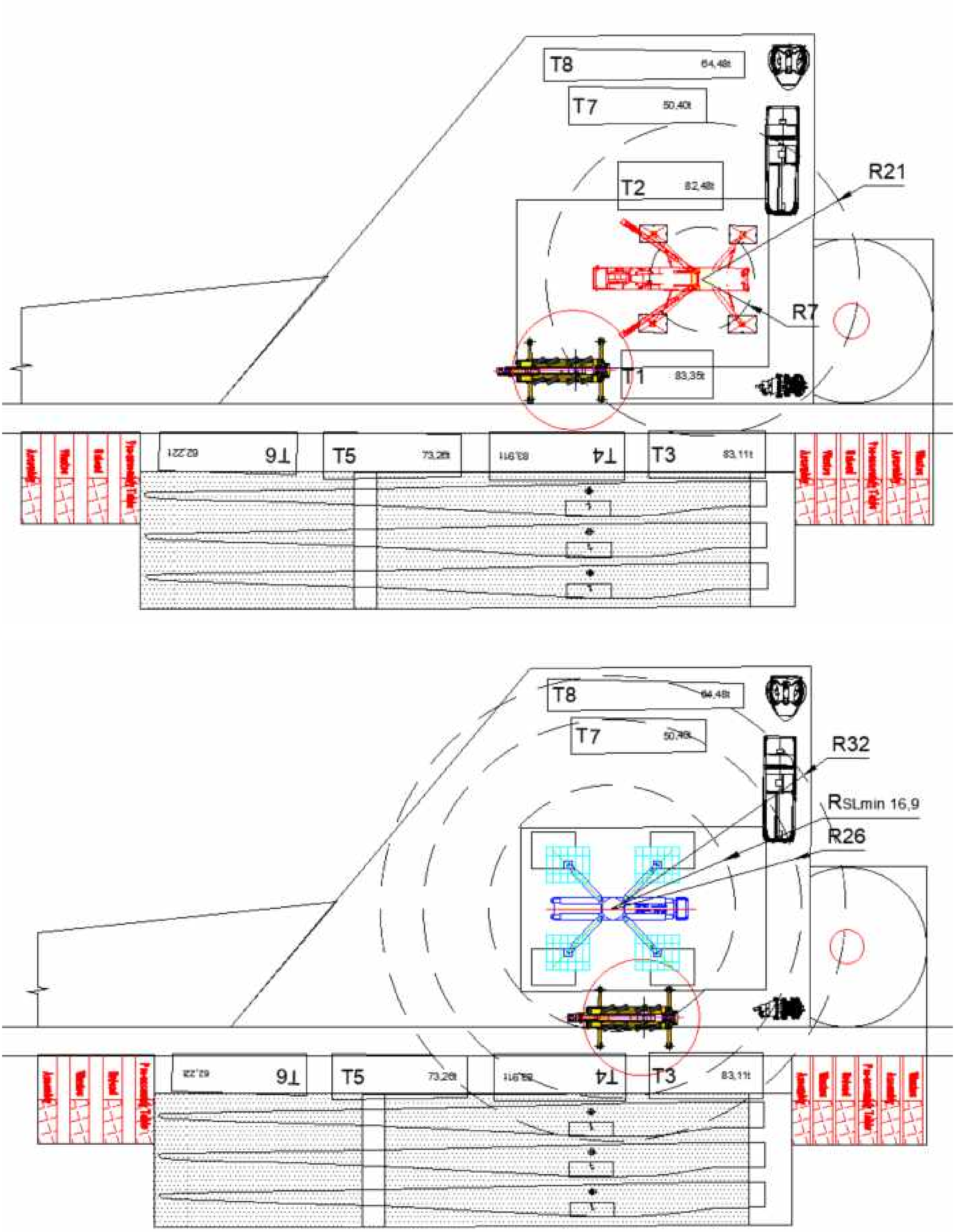


Figure 33. Model T150m - Partial storage assembling with strategy 4 in 2 phases

5.5.13. T155m tubular steel tower Hardstand with strategy 3

The sizing of the hardstand corresponds to the use of a large wide track crawler crane and not the standard crane LG1750.

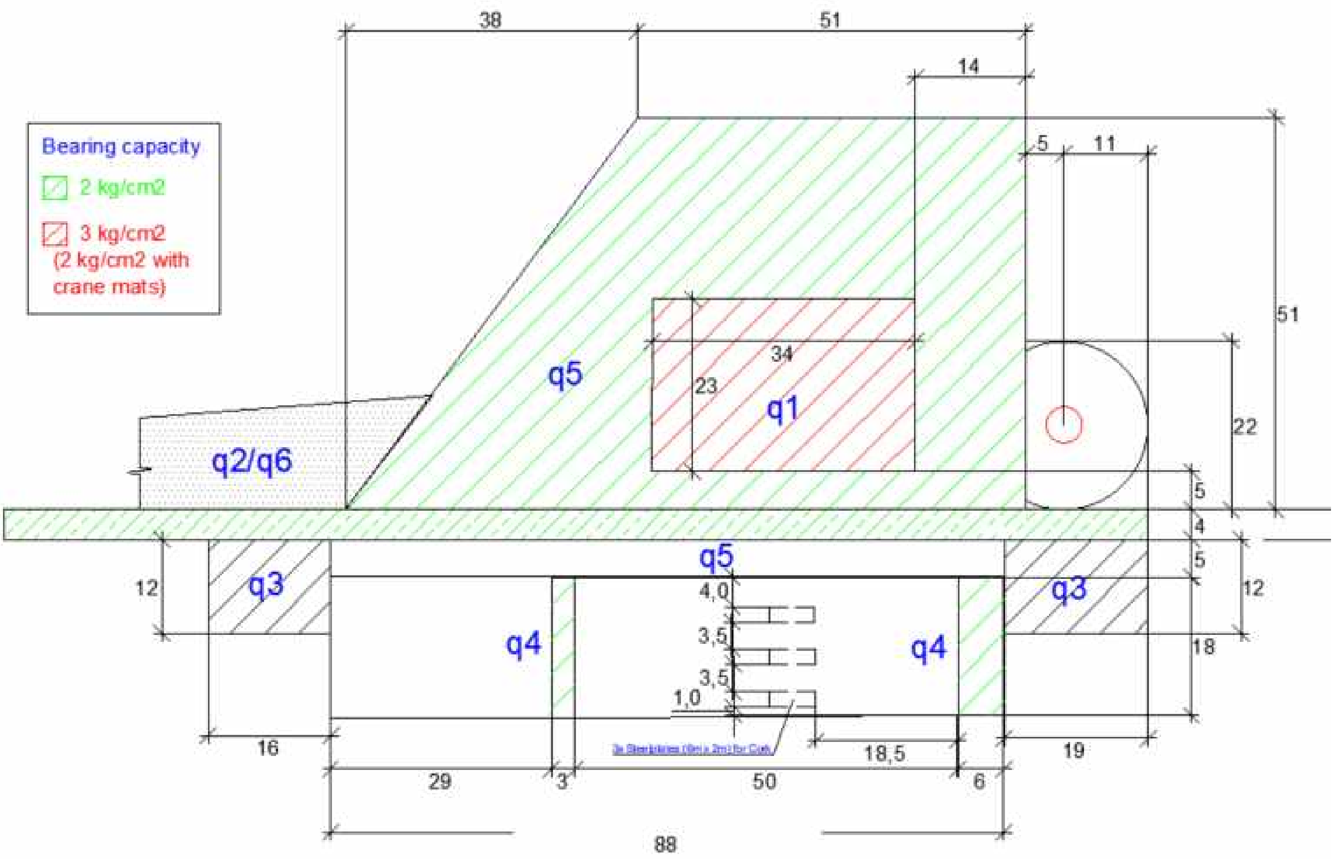
- Tailing crane offloading T155m

Storage conditions	Width x length
Total Storage	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 51m x 51m + (38m x 51m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 53m x 46m + (38m x 56m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 39. Dimensions of the areas of model T155m with strategy 3 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



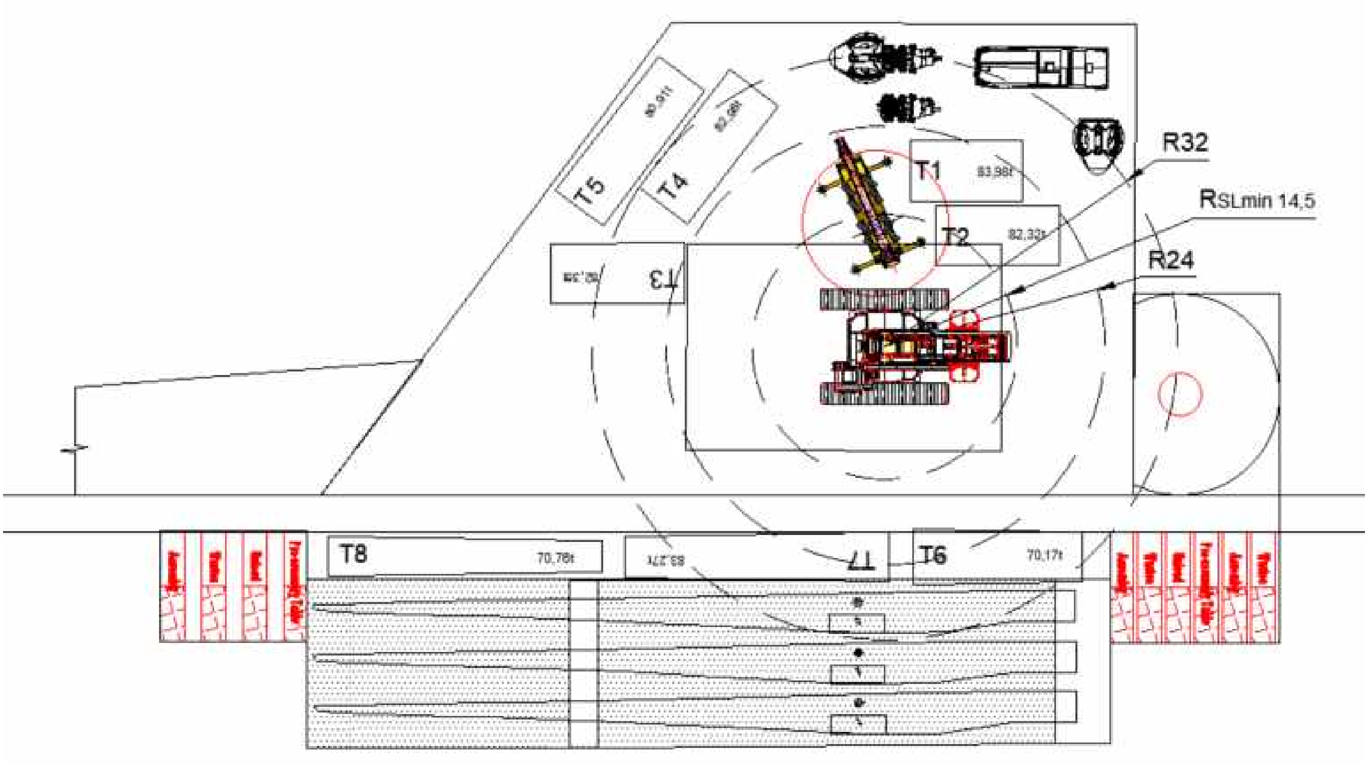
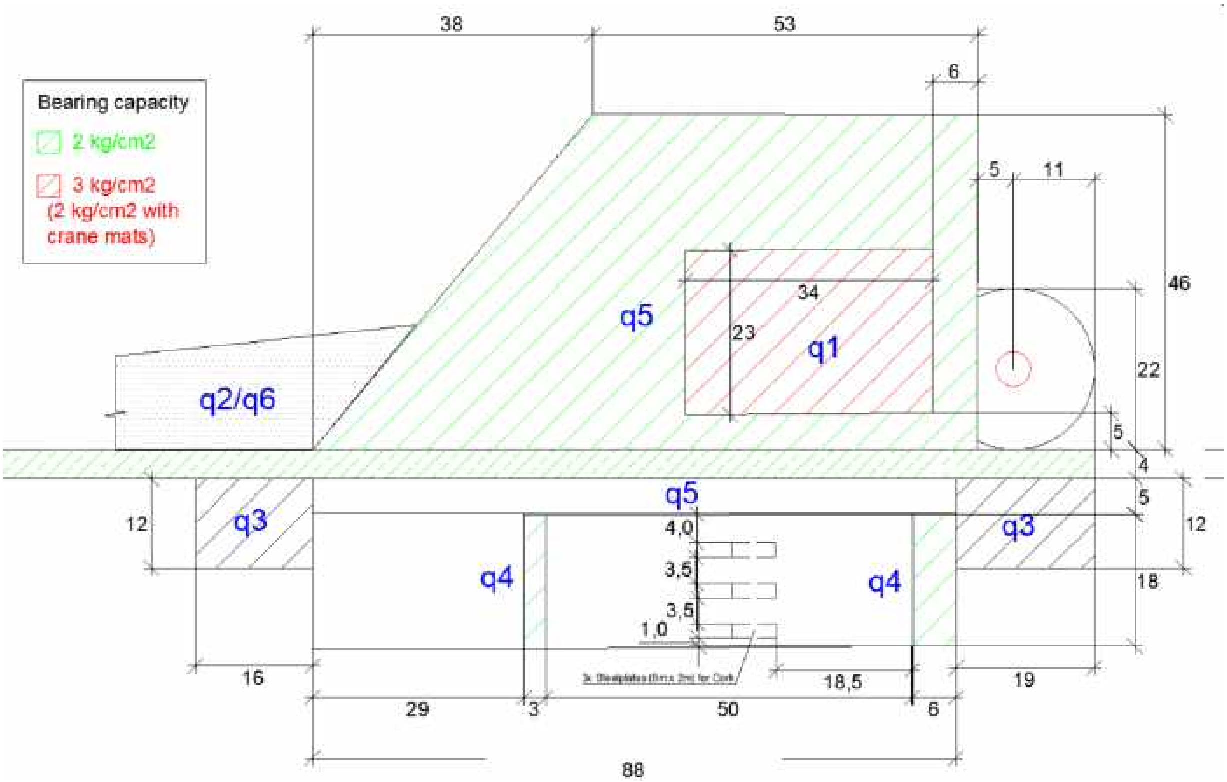


Figure 35. Model T155m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



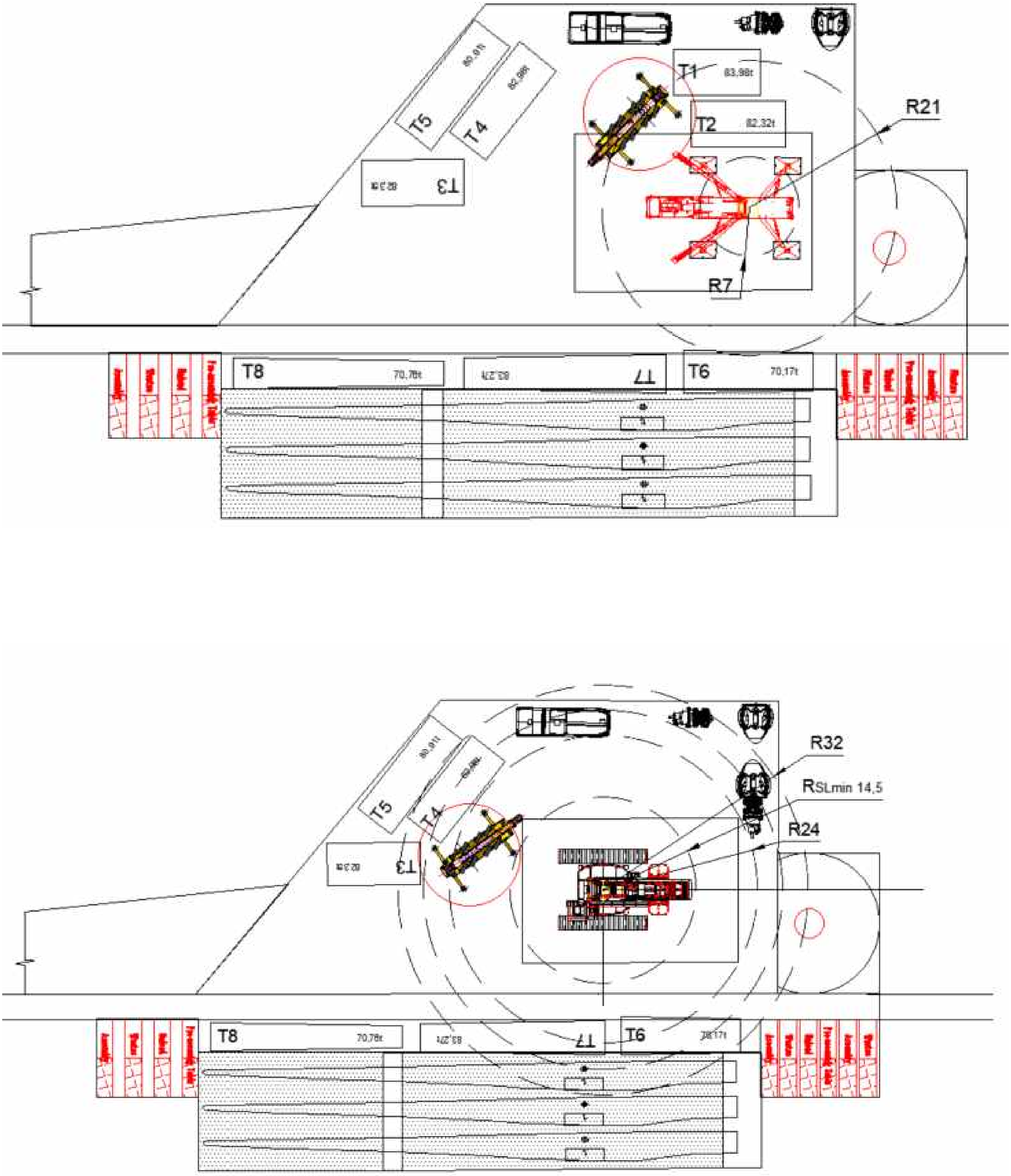


Figure 36. Model T155m - Partial storage assembling with strategy 3 in 2 phases

5.5.14. T155m tubular steel tower Hardstand with strategy 4

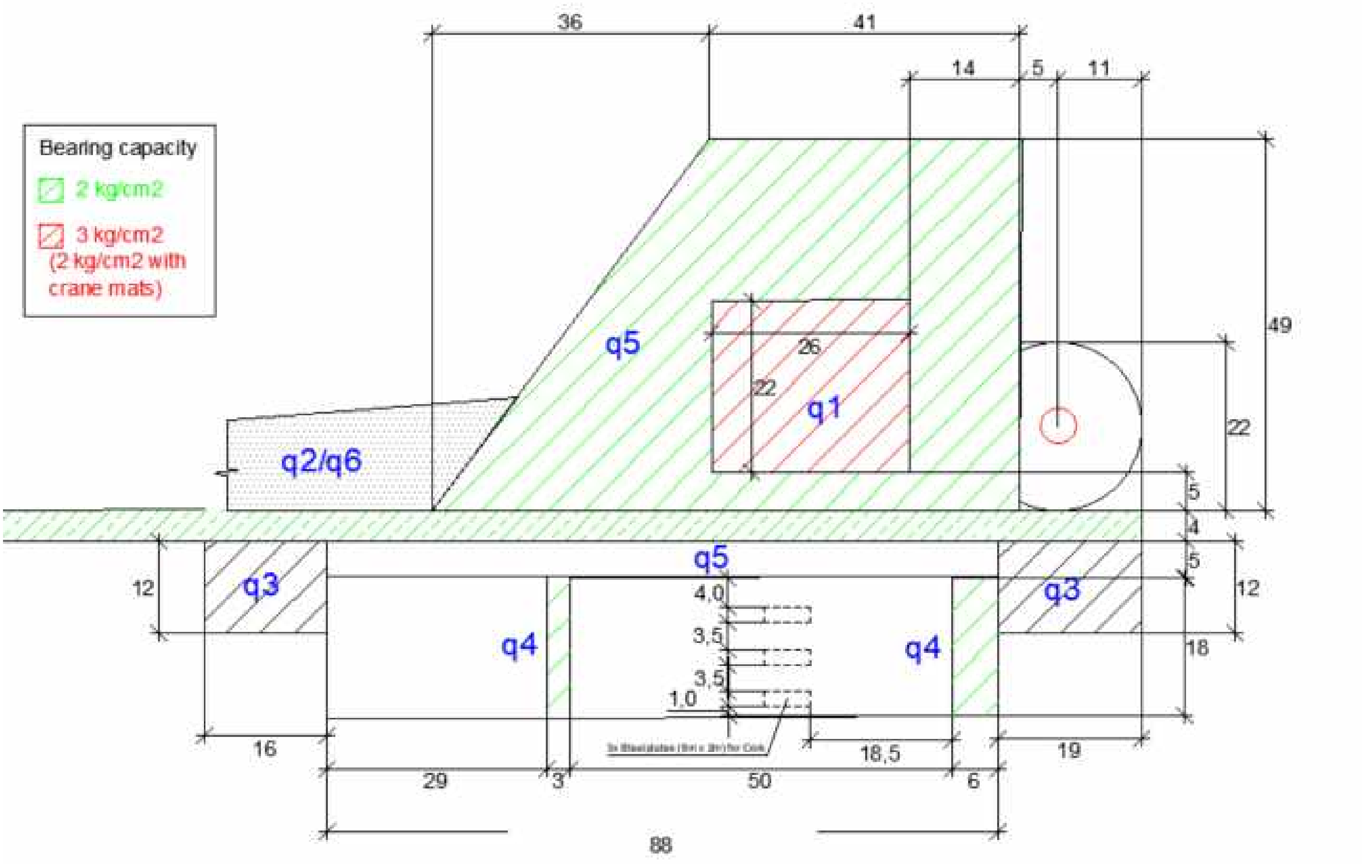
- Tailing crane offloading T155m

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 40. Dimensions of the areas of model T155m with strategy 4 – Tailing crane offloading

- Total storage – Assembly in 1 phase – STD tower



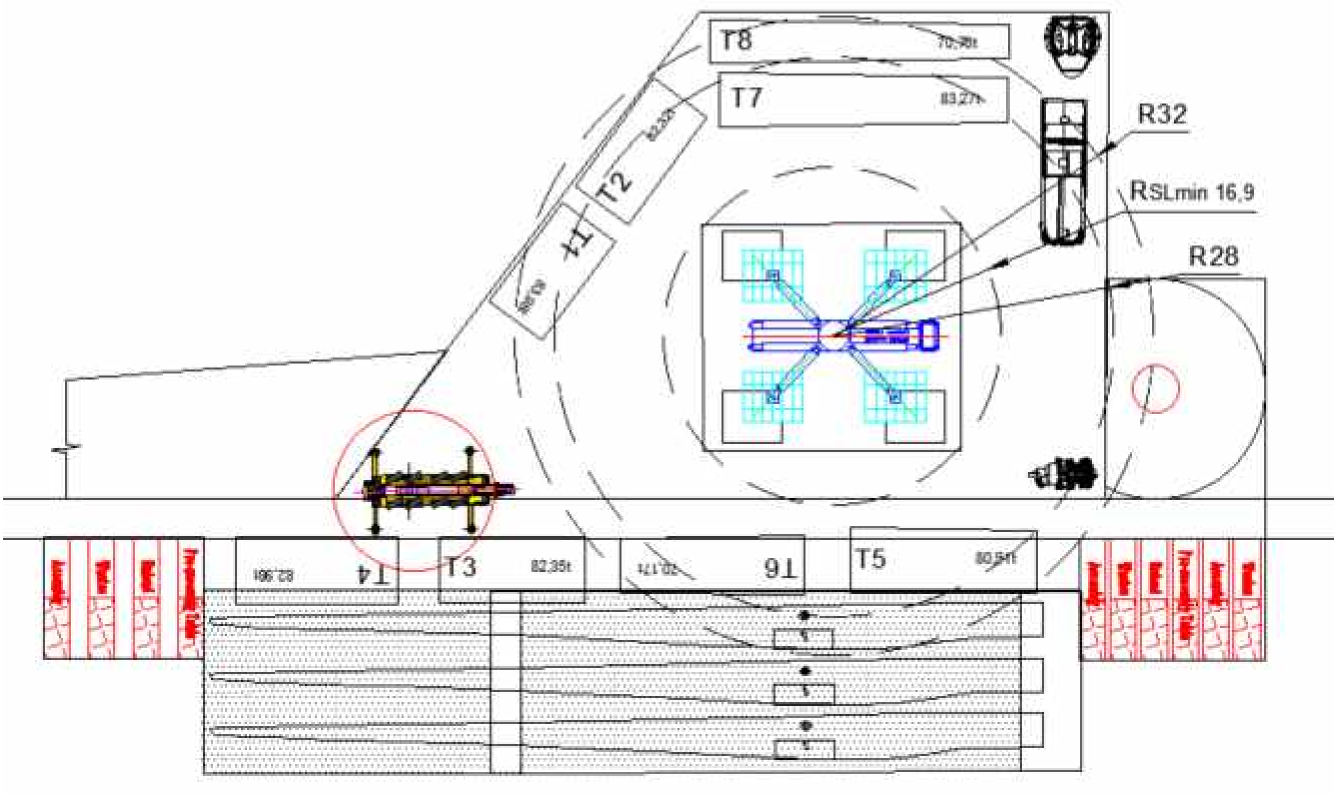
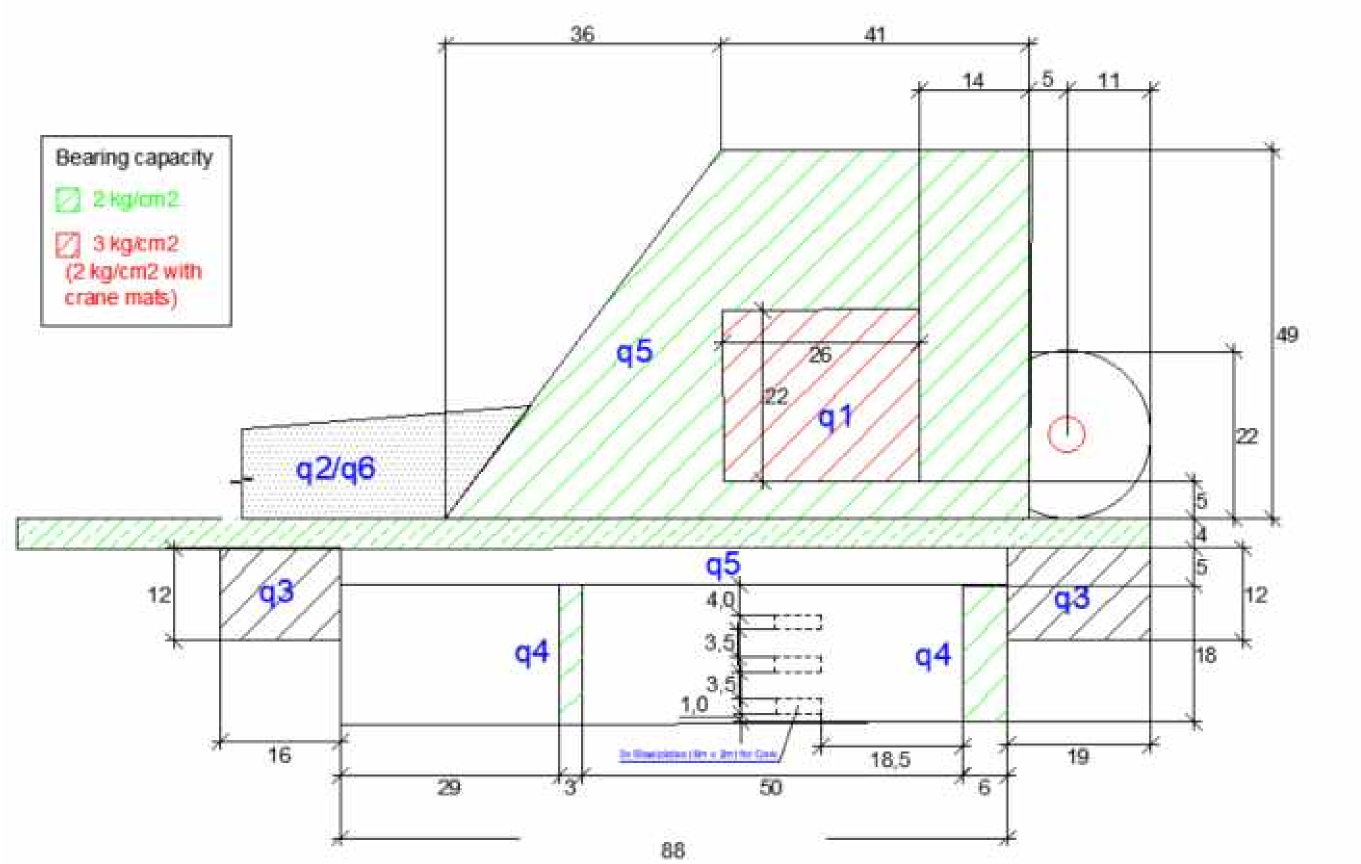


Figure 37. Model T155m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



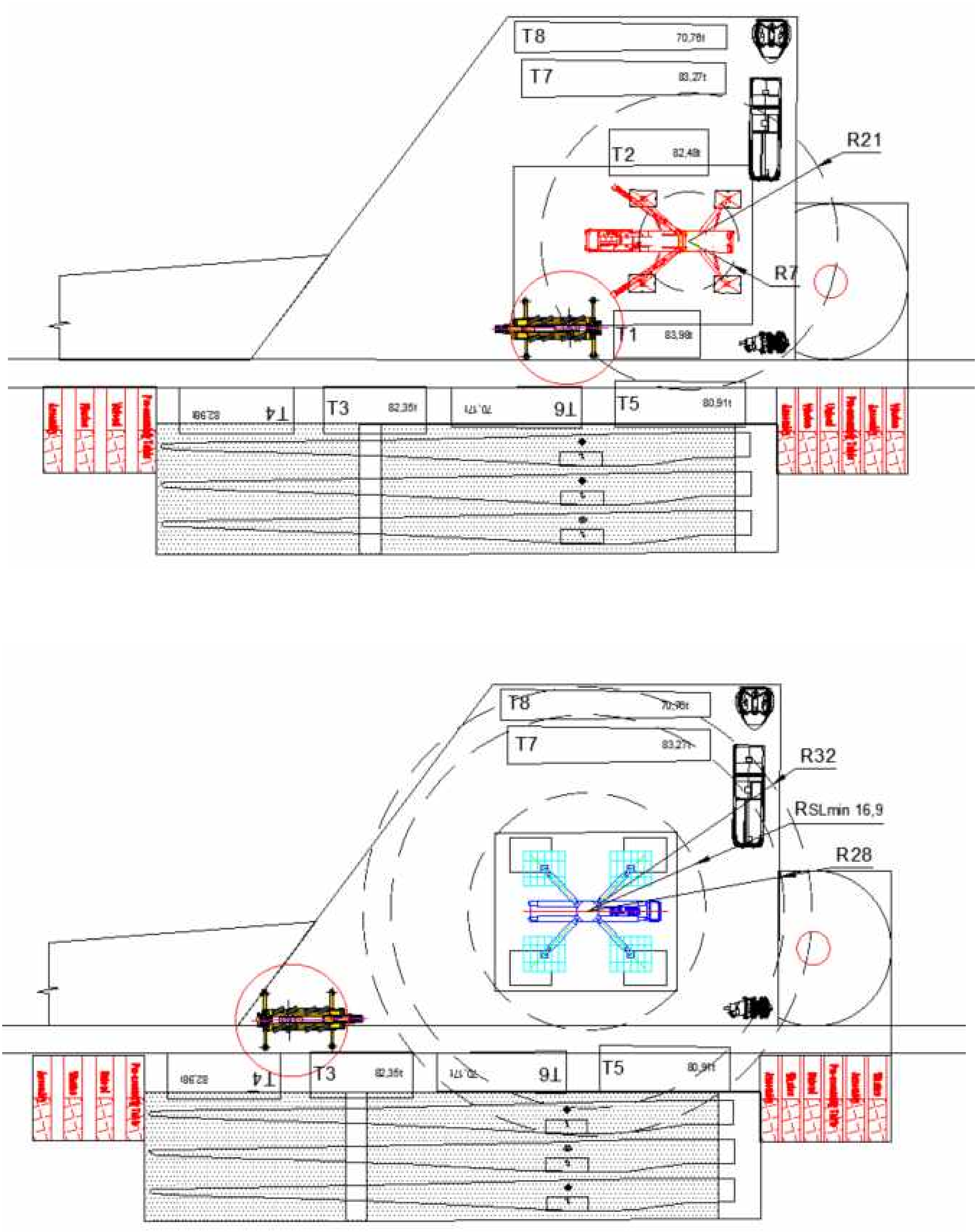


Figure 38. Model T155m - Partial storage assembling with strategy 4 in 2 phases

5.5.15. T165m & T165m MB - WT tubular steel tower Hardstand with strategy 3

The sizing of the hardstand corresponds to the use of a large wide track crawler crane and not the standard crane LG1750.

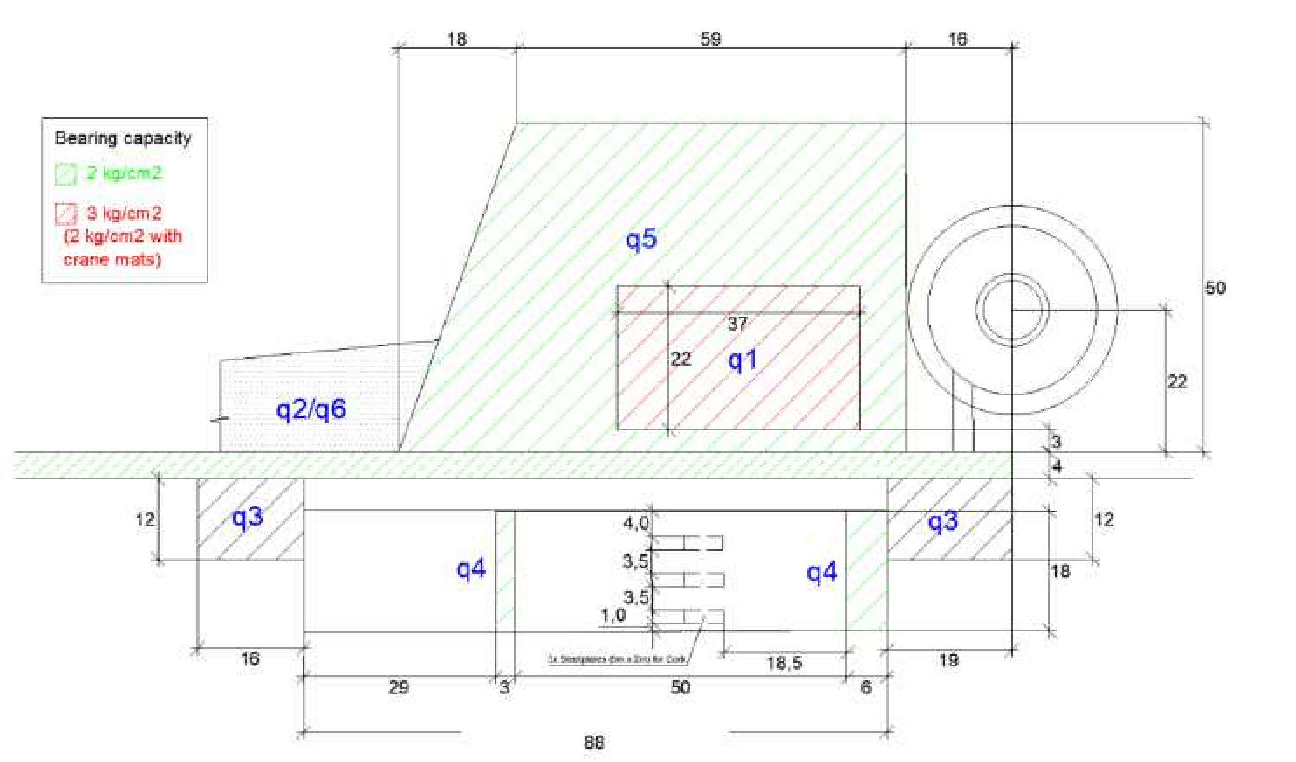
- Tailing crane offloading T165m&T165-MB

Storage conditions	Width x length
Total Storage	q1: 51m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 59m x 50m + (18m x 50m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 51m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 53m x 42m + (14m x 42m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.3 Road width

Table 43. Dimensions of the areas of model T165m MB – WT with strategy 3 – Tailing crane offloading

- Total storage – Assembly in 1 phase



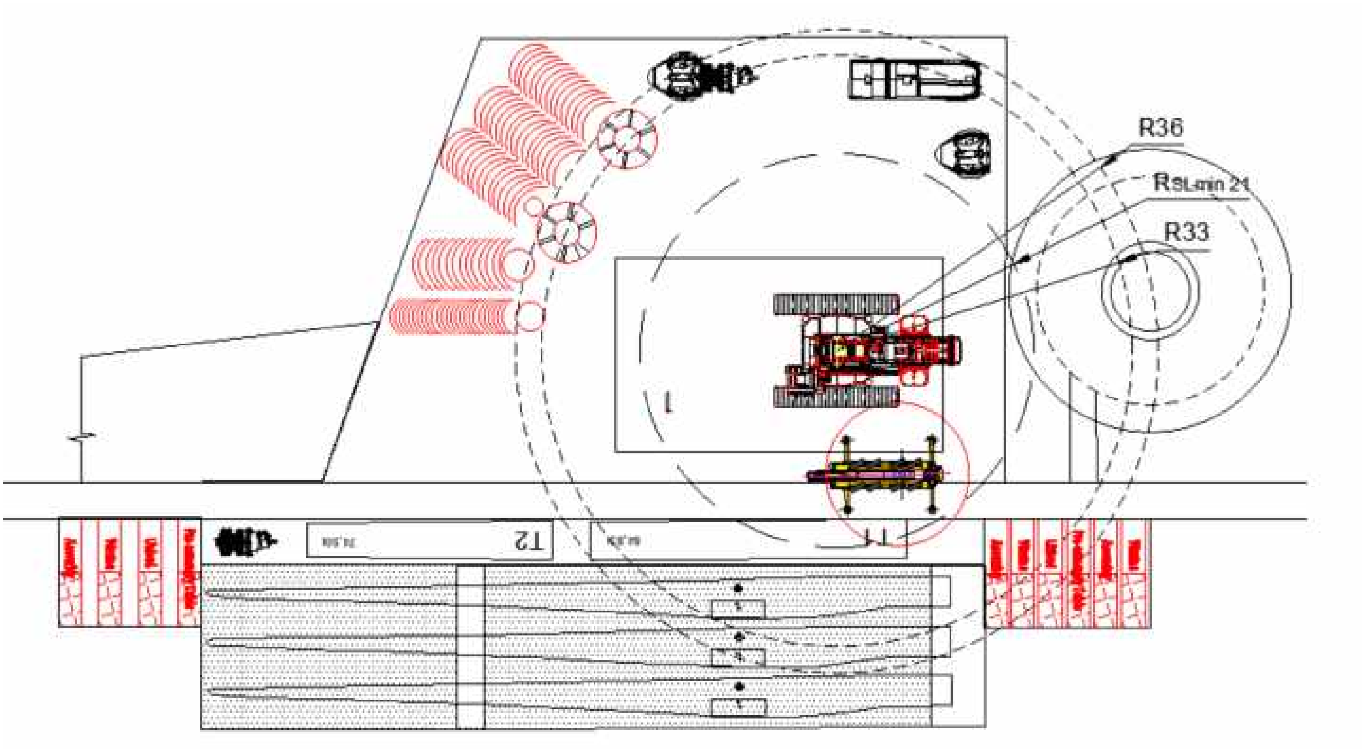
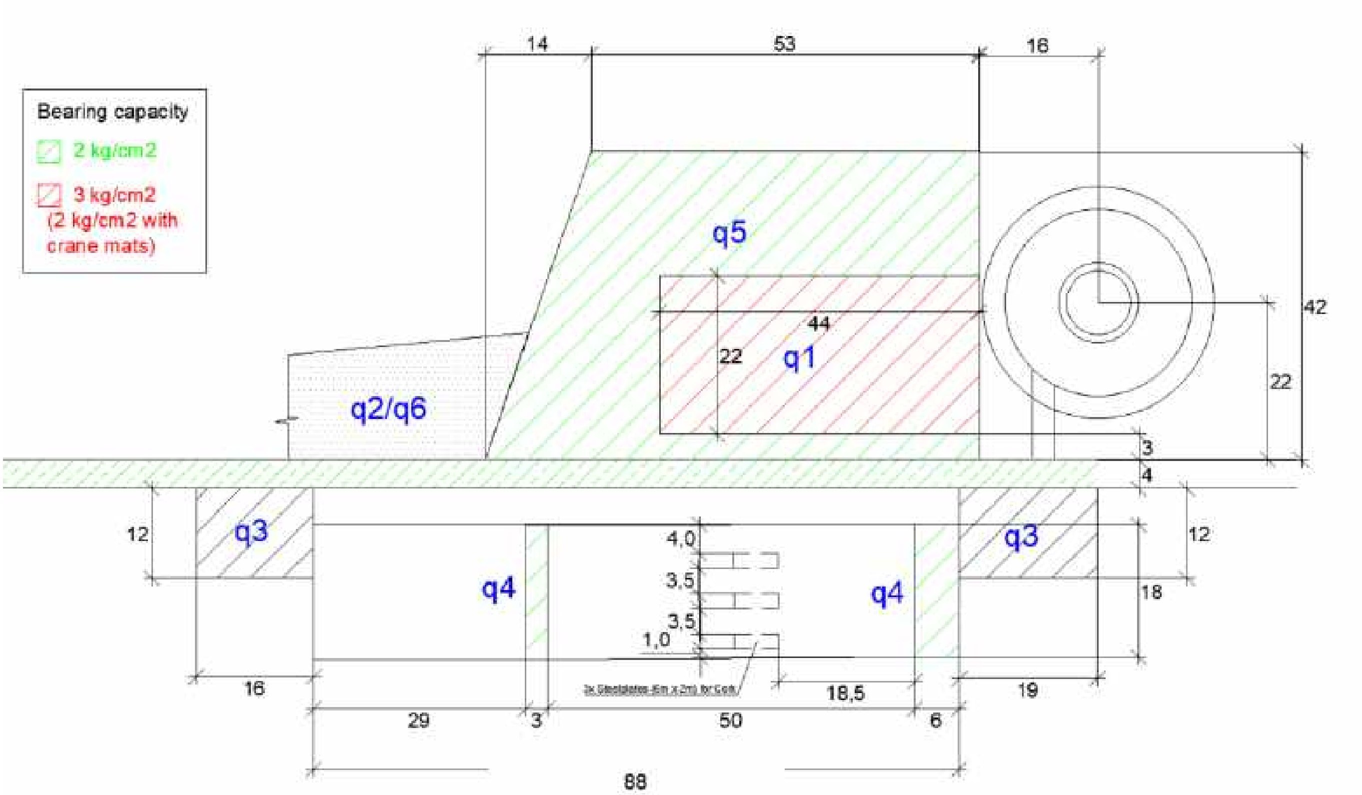


Figure 43. Model T165m MB – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



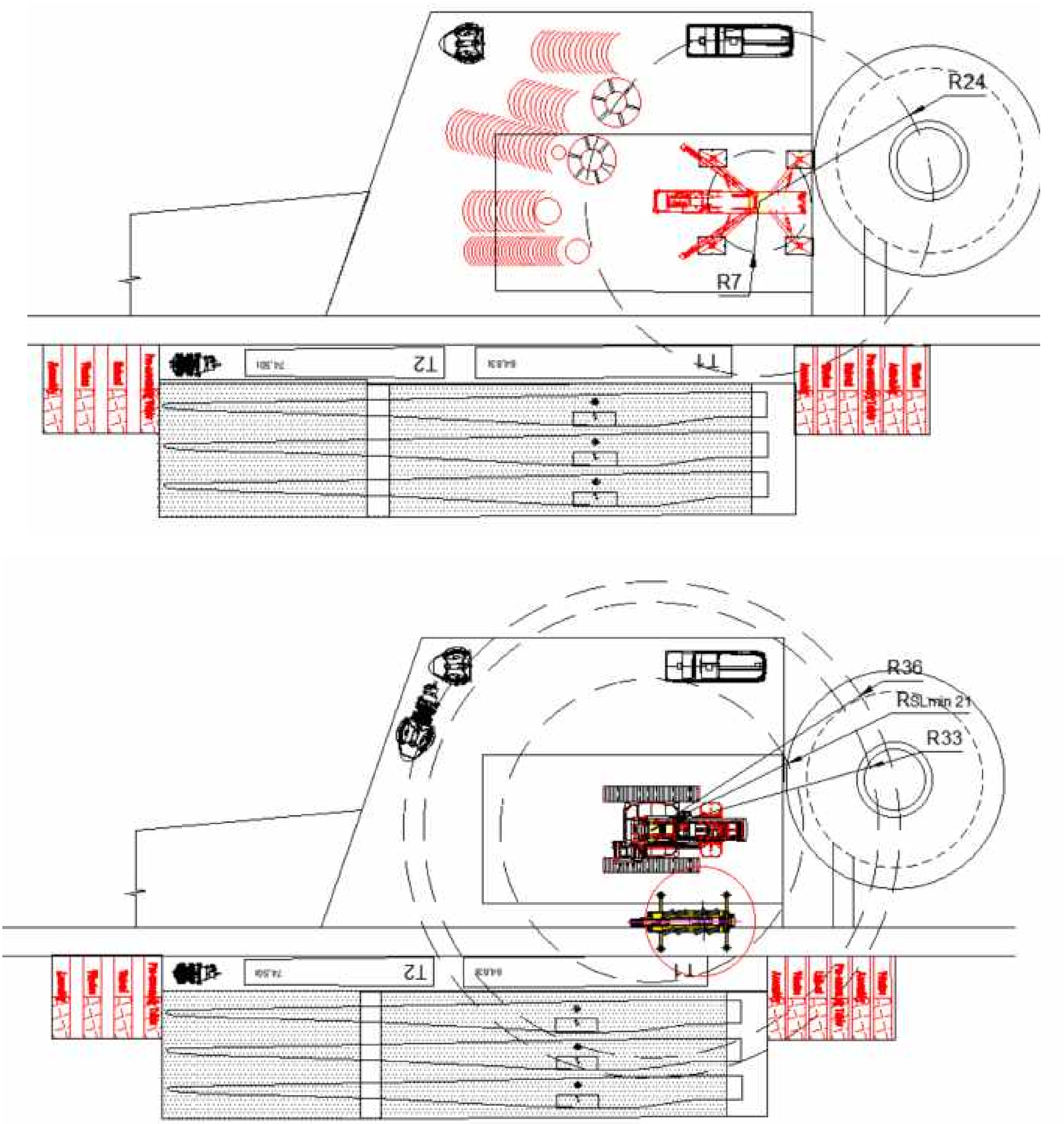


Figure 44. Model T165m MB – WT – Partial storage assembling with strategy 3 in 2 phases

5.5.16. T165m & T165m MB – WT tubular steel tower Hardstand with strategy 4

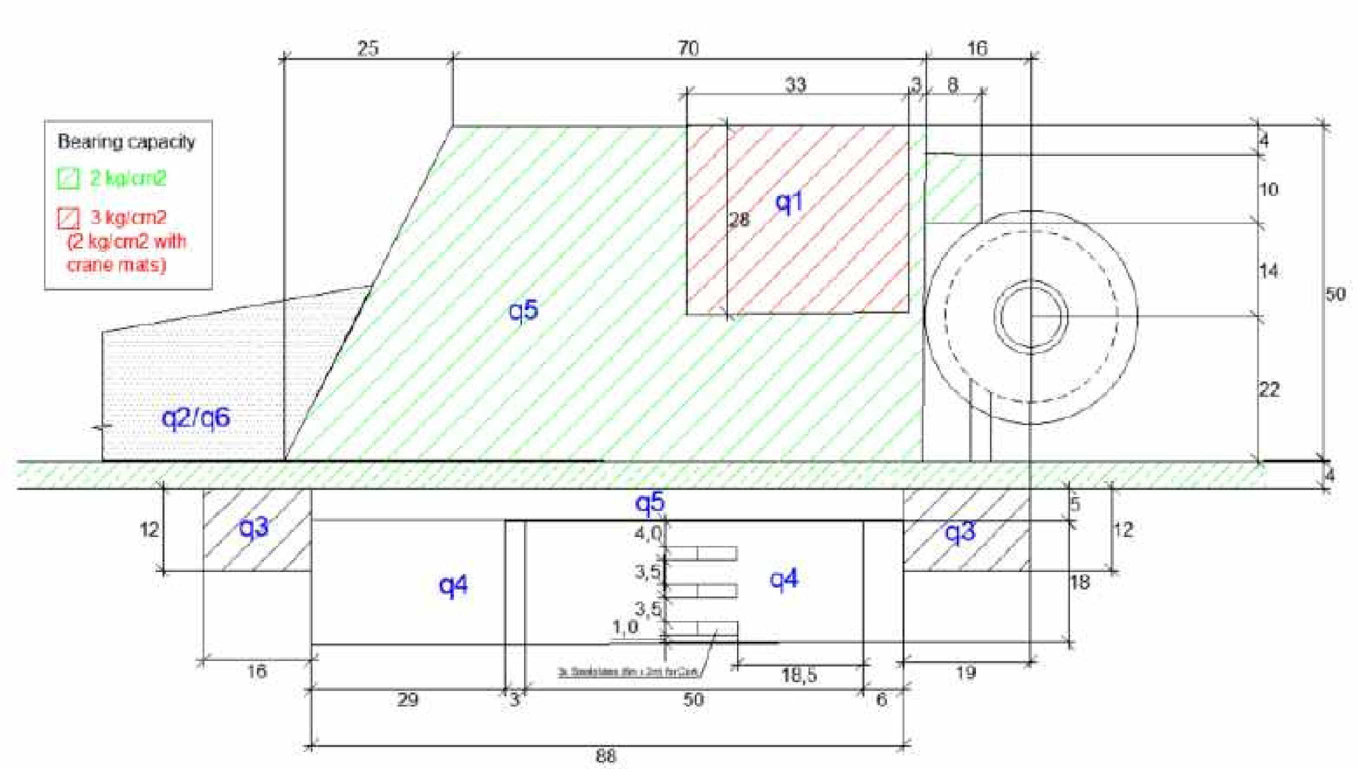
- Tailing crane offloading T165m&T165-MB

Storage conditions	Width x length
Total Storage	q1: 33m x 28m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 70m x 50m + (25m x 50m)/2 + 8m x 10m - q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 33m x 28m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 51m x 50m + (29m x 50m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6 : Dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 44.. Dimensions of the areas of model T165m MB – WT with strategy 4 – Tailing crane offloading

*Referred to 3.1.3 Road width

- Total storage – Assembly in 1phase



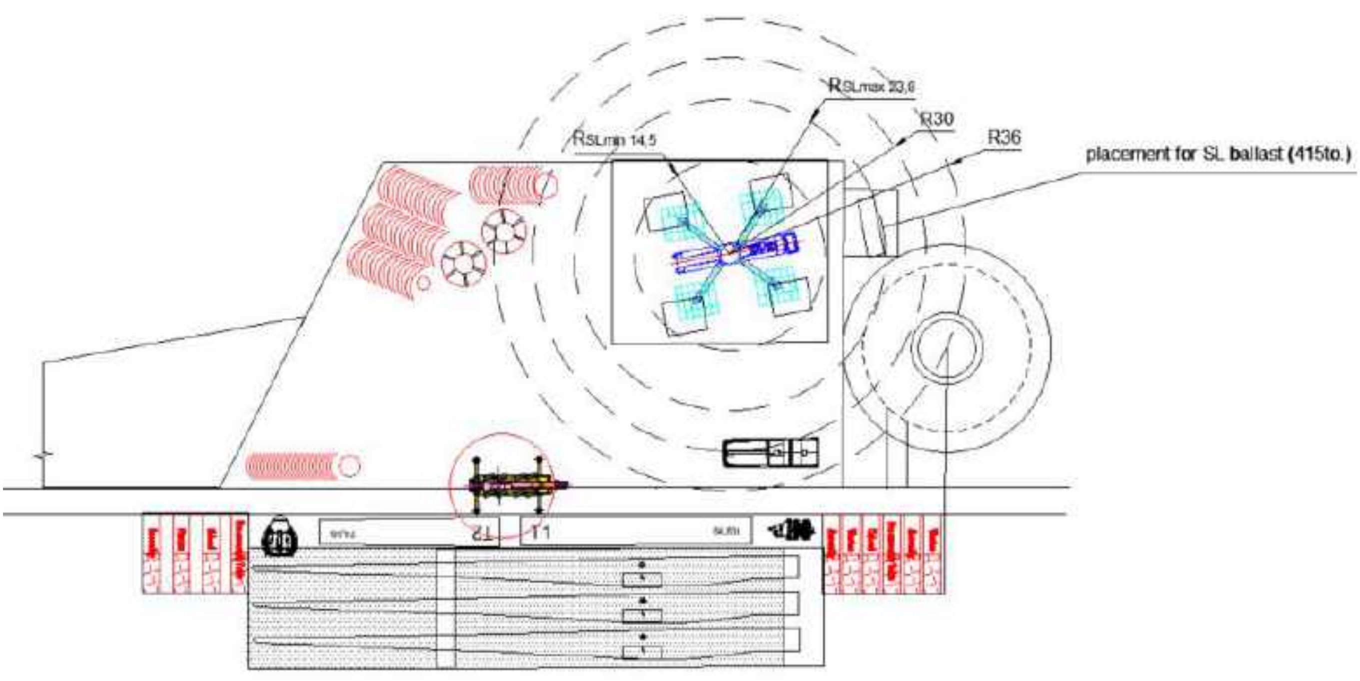
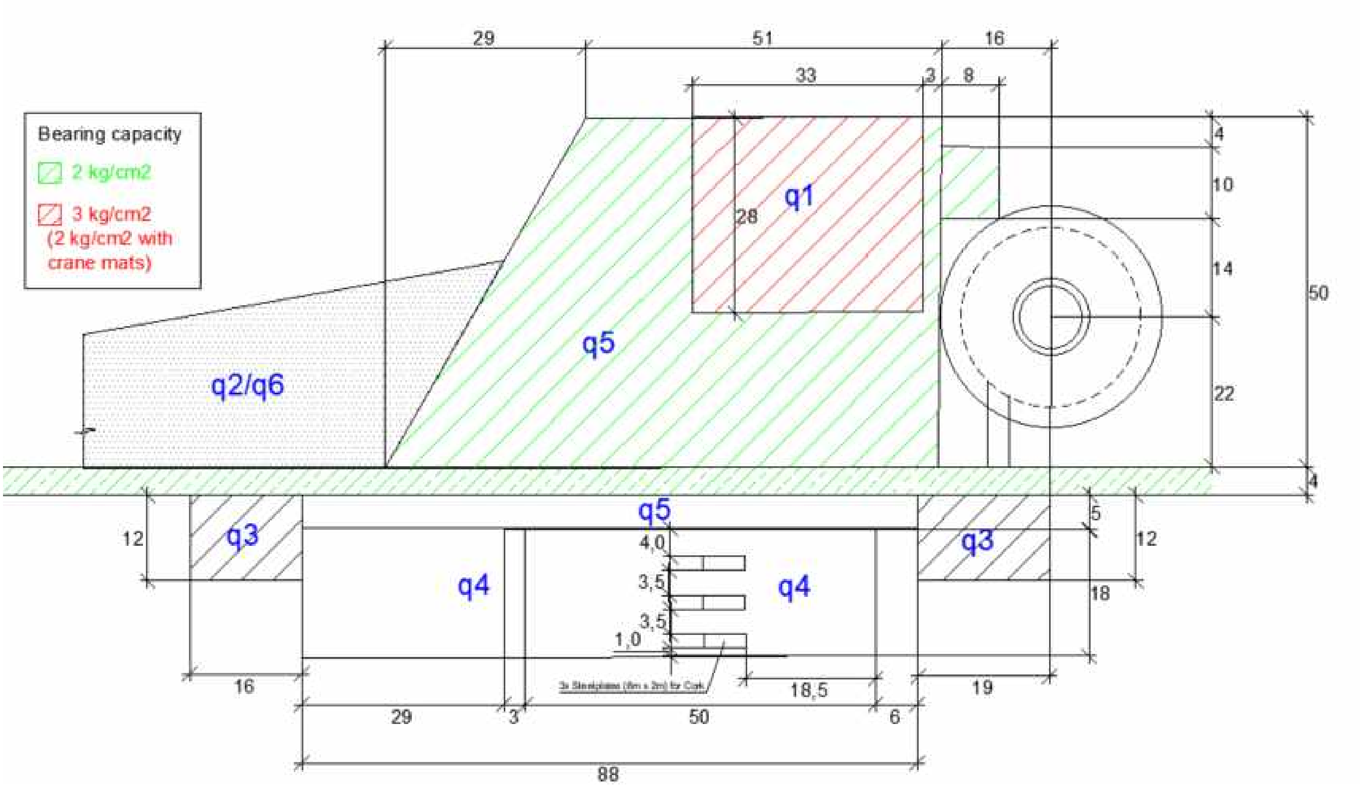
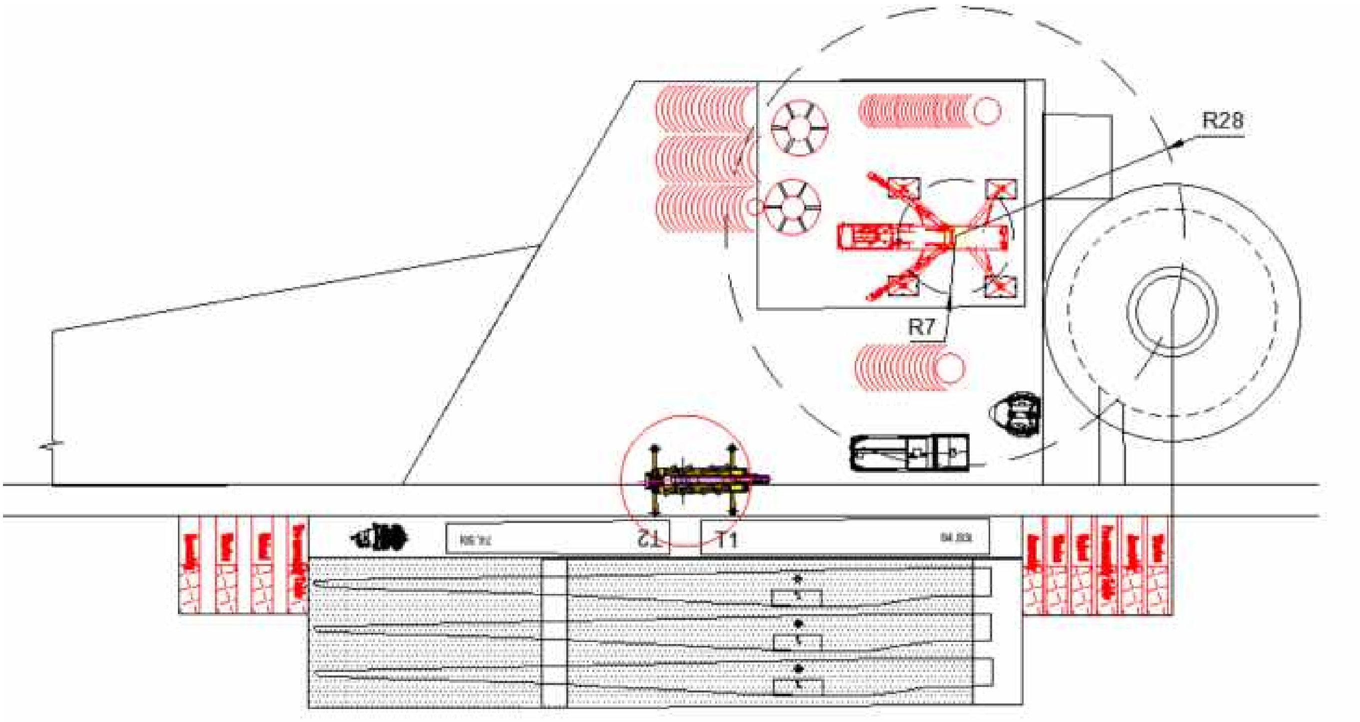


Figure 45. Model T165m MB – WT – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)





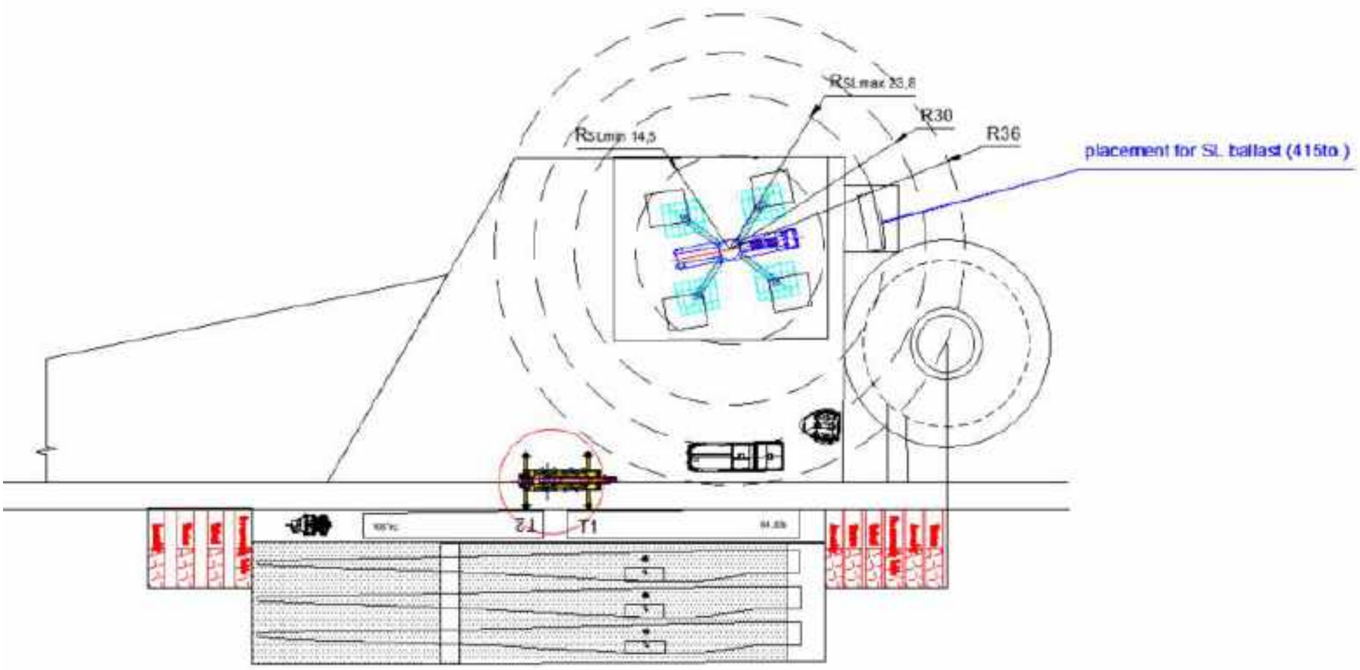


Figure 46. Model T165m MB – WT – Partial storage assembling with strategy 4 in 2 phases

5.5.17. JIT storage tubular steel tower Hardstand with strategy 3

The drawings for JIT towers:

- W/o hybrid tower and segmented tower solutions
- With estimated crane type: LG1750
- Estimated for flat foundations

In addition, the legend of the different hardstands and values that appear in the JIT drawings is included below.

Legend:

$R_{op.}$ =	estimated crane operation radius
R_{min} =	min. crane operation radius to hoist components (with specific crane type / crane configuration
R_{SLmin} =	min. crane superlift radius (min. outer SL rotation diameter)
q1 =	hardstand for main crane
q2 =	hardstand for assistant crane
q3 =	storage area for containers and miscellaneous items
q4 =	blade storage area with blade fingers
q5 =	storage area for main components
q6 =	area for crane boom assembly / disassembly
q7 =	free obstacles area for rotation superlift / suspended ballast of main crane
X =	distance q1 to q5 boundary line
Y =	distance q1 to site road
Dim. L x W =	dimensions length x wide
Area =	area calculation

Figure 47. Legend to define different values of the hardstand drawings

						q1		q3		q4		q5	
WTG - Type	HH [m]	no. of steel towersec.	Rop. [m]	X [m]	Y [m]	dim. L x W [m]	area [m²]	dim. L x W [m]	area [m²]	dim. L x W [m]	area [m²]	dim. L x W [m]	area [m²]
SG5.X - 155	90	4	24	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	102.5	4	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	107.5	4	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	113.5	5	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	117.5	5	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	120.5	5	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 155	122.5	5	27	7	3	29x18	522	(19x12)+(16x12)	420	83x18	1494	(83x5) + (35x44) + ((30*44)/2) - q1	2093
SG5.X - 170	100	4	27	7	3	29x18	522	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	2118
SG5.X - 170	101.5	6	27	7	3	29x18	522	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	2118
SG5.X - 170	115	5	27	7	3	29x18	522	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	2118
SG5.X - 170	135	6	30	7	5	29x18	522	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	2118
SG5.X - 170	145	8	32	6	5	34x23	782	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	1858
SG5.X - 170	155	8	32	6	5	34x23	782	(19x12)+(16x12)	420	88x18	1584	(88x5) + (35x44) + ((30*44)/2) - q1	1858

Figure 48. Dimensions of main hardstands

- Tailing crane offloading

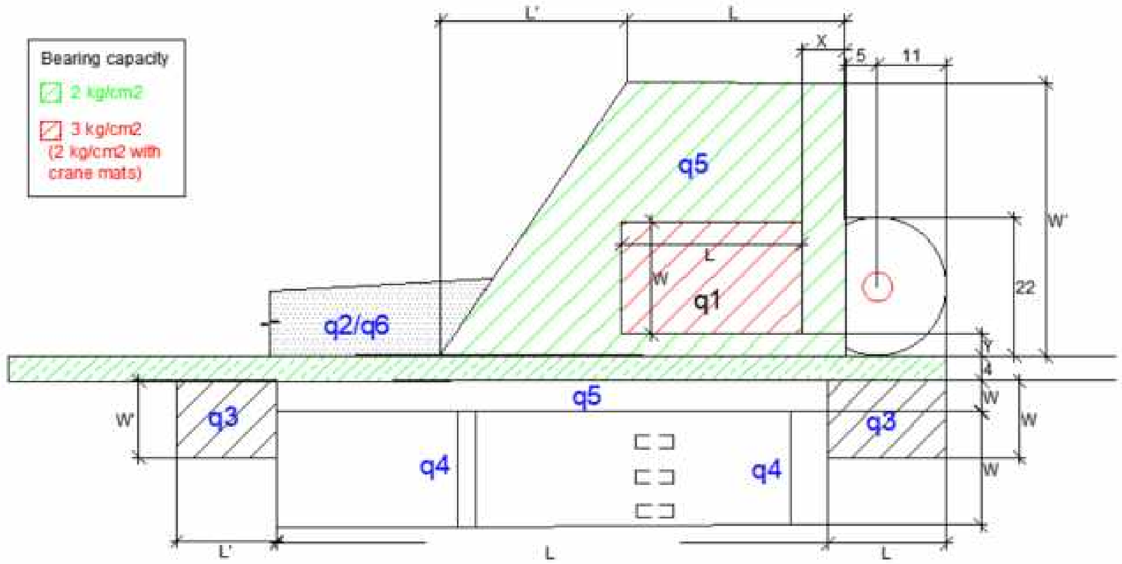
Storage conditions	HH	Width x length
JIT	100 110.5 115 135 **	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 35m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
JIT	145 150 155	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 35m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 13. Dimensions of the areas of JIT storage – Tailing crane offloading

*Referred to 3.1.3 Road width

** The required dimensions for SE&A JIT hardstands tower height T115m and T135m can be found in document reference INS-62237 Site JIT hardstands in SE&A wind farms.

- Total storage – Assembly in 1 phase



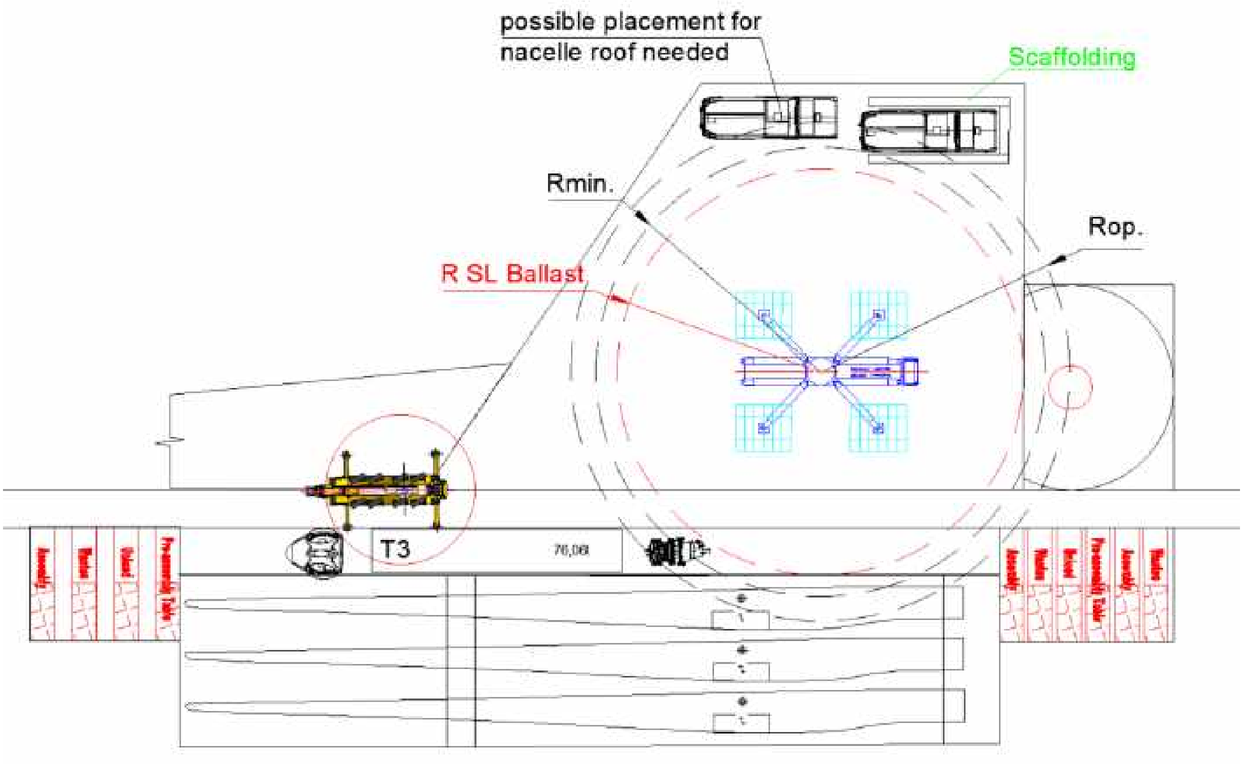


Figure 49. JIT storage reference hardstand

DISCLAIMER:

The drawings and dimensions shown in the SSR represent standard situations with given assumptions and requirements. The drawings can be project-specifically modified and / or improved, depending on specific conditions or crane used what may have impact in CNS/ LOG cost and planning.

This can / should be done by the individual SGRE regions or by the customer to generate optimized hardstand layouts for each site.

2.3. CUMPLIMIENTO DELOS CODIGOS DE RED PARA CONEXIÓN DE PARQUES EÓLICOS

Documento de cumplimiento de los protocolos de conexión para los aerogeneradores SIEMENS GAMESA

SIEMENS Gamesa RENEWABLE ENERGY

GCODER_SPAIN_SG 5.X

Document ID and revision	Status	Status date (yyyy-mm-dd)	Language
GD468732 R3		2022-02-28	en-US

Original or translation of	RDS-PP®
Original	

File name
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Updates made since the previous revision
Added new grid code documentation (NTS V2.1 and BOE-A-2021-904), New Template, New Grid capability and certifications status. Syntax Update.

Confidentiality:	Deliverable Type	Doc Classification:
3 / CUSTOMER INFORMATION	S12 - General Characteristics Manual	STD - Support

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Table of contents

1. Aim ... 3
2. Scope ... 3
3. Acronyms, Definitions and Legend ... 4
4. Country Regulations Overview ... 7
5. Requirements Analysis ... 8
5.1. Rated Operation Range ... 8
5.1.1. Frequency Operation Range ... 8
5.1.2. Voltage Operation Range ... 10
5.1.3. Voltage/Frequency Operation Area ... 14
5.1.4. Reactive Power Operation Range ... 17
5.2. Fault Ride Through Support ... 21
5.2.1. Current Support ... 21
5.2.2. Active Power Recovery After Clearance ... 23
5.2.3. Consecutive Voltage Dips ... 24
5.3. Active Power / Frequency Regulation ... 25
5.4. Reactive Power / Voltage Regulation ... 30
5.5. Power Quality ... 33
5.6. Communications ... 34

5.7. Protections 36
5.8. Electrical Simulation Models 37
5.9. WF Simulation/Test/Certification 39
5.10. Special Requirements 41
5.10.1. Phase Jump 41
5.10.2. Inertia Emulation 42
5.10.3. Power Oscillations Damping (POD) 44
5.10.4. System Strength 45
5.10.5. Reconnection Blockage / Synchronization to the Grid 46
6. Aspects to Clarify 47
6.1. Active Power/Frequency regulation 47
6.2. Frequency Restoration 48
7. Summary 49
8. References 51

1. Aim

This document analyses the capabilities of Wind Turbine Generators (WTGs) developed by Siemens Gamesa Renewable Energy (SGRE) against the Grid Code requirements applicable **Spain** for the connection of Wind Farms (WF) to the **transmission and distribution** power grid. The main objective of this document is to provide a general overview of the compliance level of a WF with SGRE WTGs and SCADA/WF regulators.

2. Scope

The document considers **SG 5.X-170** platform together with the SCADA and WF regulator developed by SGRE.

It is important to note that most requirements are applicable at the Point of Common Coupling (PCC) of the WF and not directly at each of the WTGs' terminals. For this reason, the capabilities analysis is carried out with two different approaches depending on the requirement:

- ► Requirements for which WF compliance depends fundamentally on the WTG and/or SCADA/WF regulator capabilities (e.g. frequency operation range, fault ride through support, active power/frequency regulation…) → For these, an assessment of the WF compliance level is provided based on WTG and/or SCADA/WF regulator capabilities.
- ► Requirements for which the WTG and/or SCADA/WF regulator capabilities are only a factor for the WF compliance (e.g., voltage operation range, reactive power operation range, power quality…) → For these the WTG and/or SCADA/WF regulator capabilities to contribute to the WF compliance are provided.

The most appropriate converter configurations will be considered for the Grid Code analysis so that the requirements are fulfilled at the greatest possible extent but at the lowest cost. Considering the Grid Code analyzed in this document, the converters have been selected according Table 1 and their compliance with the Grid Code analyzed.

Platform	Converter
SG5.X-170	-

Table 1 Selected Converters.

3. Acronyms, Definitions and Legend

Acronym	Description
AM	Application Mode
BOP	Balance of Plant
CCU	Converter Control Unit
DSO	Distribution System Operator, or the relevant governing body regarding grid connection requirements
EMT	Electromagnetic Transient
FSM	Frequency Sensitive Mode
GC	Grid Code
GCA	Grid Code Analysis
GE	Global Engineering
GE-GC	Global Engineering- Grid Connection
HV	High Voltage
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
PD	Product Development team
LFSM-O	Limited Frequency Sensitive Mode - Overfrequency
LFSM-U	Limited Frequency Sensitive Mode - Underfrequency
LV	Low Voltage
MV	Medium Voltage
N/A	Not Applicable
OLTC	On Load Tap Changer
OVRT	Overvoltage Ride Through
PCC	Point of Common Coupling
PD	Product Development (PD) team
PGM	Power Generating Module
PLC	Programmable Logic Controller
PSS	Power System Stabilizer
p.u.	Per Unit
RMS	Root-Mean-Square
ROCOF	Rate of Change of Frequency

SCADA	Supervisory Control and Data Acquisition
SGRE	Siemens Gamesa Renewable Energy
SSCI	Sub-Synchronous Control Interactions
STATCOM	Static Synchronous Compensator, also known as SVG
TSO	Transmission System Operator, or the relevant governing body regarding grid connection requirements
UVRT	Undervoltage Ride Through
WF	Wind Farm
WFR	Wind Farm Regulator
WTG	Wind Turbine Generator

Table 2 Acronyms.

Definition	Description
$\cos\varphi$	Power factor
f_n	Nominal frequency
I_1	Positive Sequence Current
I_2	Negative Sequence Current
I_q	Reactive Current
I_r	Rated Current
P	Active Power
P_n	Nominal Active Power
Q	Reactive Power
Tamb	Rated Ambient Temperature
THD	Total Harmonic Distortion
U_n	Nominal Voltage

Table 3 Definitions.

Legend	Description
✔ Compliance	Compliance is expected
Development in Progress	A SCADA or WTG development is planned or underway in order to assure compliance
⚠ Request development upon need	A specific development is required and shall be requested when a project needs to comply with this requirement.
? To be Clarified	The requirement is not clear, or information is missing. Therefore, it shall be clarified with the Operator.
✕ Non-compliance	The requirement cannot be fulfilled.
Wind Farm Study Needed	Wind Farm Study Needed

Table 4 Legend.

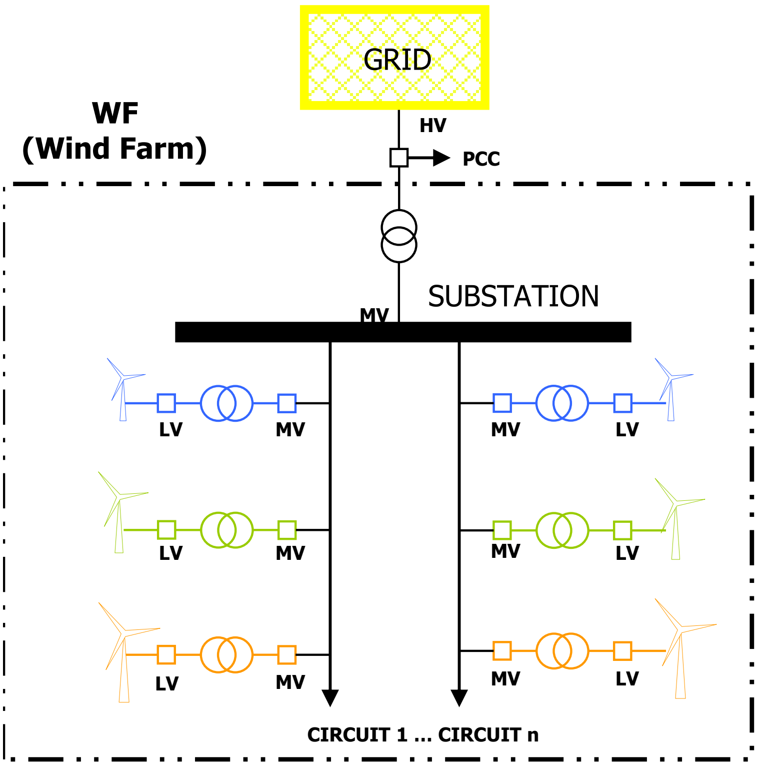


Figure 1 Conceptual scenario.

SIGN CONVENTION FOR REACTIVE POWER:

The following sign convention regarding reactive power is used for the whole analysis:

- Reactive power absorption: The WTG imports reactive power from the public power grid. This operation is equivalent to a coil/reactor or an underexcited synchronous generator.
- Reactive power supply: The WTG exports reactive power to the public power grid. This operation is equivalent to a capacitor or an overexcited synchronous generator.

The terms “inductive reactive power” and “capacitive reactive power” are intentionally omitted in order to avoid any confusion.

4. Country Regulations Overview

The purpose of the analyzed document procedure is to establish minimum requirements for design, equipment, operation, commissioning and safety of the facilities connected to the Spanish mainland electrical system transport network, as well as the production and demand facilities in those aspects that they are applicable because of their influence on the electrical system as a whole, both from the Spanish mainland perspective and from the interconnected European system.

In this sense, the subject of the analyzed procedure is the establishment of the technical requirements and procedures established in the Commission Regulation (EU) 2016/631 of April 14, 2016, which establishes a network code on the connection requirements of generators to the network and complete the development of those requirements required by the Regulation; as well as technical aspects that, a priori, because of their local influence (not "cross-border") are outside the scope of European regulations but that have total relevance in the operation and safety of the electrical system.

The documents to be analyzed are:

- **BOE-A-2020-7439, "Real Decreto 647/2020, de 7 de julio, por el que se regulan aspectos necesarios para la implementación de los códigos de red de conexión de determinadas instalaciones eléctricas", 08/July/2020** [1]**.**
- **BOE-A-2020-8965, "Orden TED/749/2020, de 16 de julio, por la que se establecen los requisitos técnicos para la conexión a la red necesarios para la implementación de los códigos de red de conexión, 01/August/2020"** [2]**.**
- **"Reglamento (UE) 2016/631. Código de red sobre requisitos de conexión de generadores a la red", April/2016** [3]**.**
- **Norma técnica de supervisión de la conformidad de los módulos de generación de electricidad según el reglamento UE 2016/631, Revisión 2.1, 09/July/2021** [4]**.**
- **"P.O. 9 Información intercambiada por el operador del Sistema", 20/December/2019** [5]**.**
- **"Condiciones de Validacion y Aceptacion de los Modelos", Revision June/2020** [6]**.**
- **"Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red", Revision June/2020** [7]**.**
- **"Requisitos de los modelos de instalaciones FACTS", Revision June/2020** [8]**.**
- **BOE-A-2021-904, "Circular 1/2021, metodología y condiciones del acceso y de la conexión a las redes de transporte y distribución de las instalaciones de producción de energía eléctrica** [9]**.**

Documents [1], [2], [3], [4] and [5] will be simply known as The Grid Code.

The requirements are specified depending on the type of the PGM (power-generating module) capacity and voltage level as specified in Item 1 of "Article 8 – Evaluación de la significatividad de los módulos de generación de electricidad" of the Grid Code [1]

a) Tipo A: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea igual o superior a 0,8 kW e igual o inferior a 100 kW.
b) Tipo B: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea superior a 100 kW e igual o inferior a 5 MW.
c) Tipo C: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea superior a 5 MW e igual o inferior a 50 MW.
d) Tipo D: módulos de generación de electricidad cuyo punto de conexión sea igual o superior a 110 kV o cuya capacidad máxima sea superior a 50 MW.

For the Power Quality requirements, it is going to be considered the Annex I "Contenido de la base de datos estructural del operador del Sistema" of the document [5].

5. Requirements Analysis

5.1. Rated Operation Range

5.1.1. Frequency Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Frequency Operation Range at rated voltage and power – and the allowed power deratings – can be found in section “Rangos de Frecuencia” of document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value
	Nominal Frequency	Hz	50
	Underfrequency		
1	Underfrequency Value 1	p.u.	0.95
	Underfrequency Time 1	s	1800
2	Underfrequency Value 2	p.u.	0.97
	Underfrequency Time 2	s	1800
3	Underfrequency Value 3	p.u.	0.97
	Underfrequency Time 3	s	continuous
4	Underfrequency Value 4	p.u.	0.97
	Underfrequency Time 4	s	continuous
5	Underfrequency Value 5	p.u.	0.97
	Underfrequency Time 5	s	continuous
	Overfrequency		
1	Overfrequency Value 1	p.u.	1.03
	Overfrequency Time 1	s	1800
2	Overfrequency Value 2	p.u.	1.02
	Overfrequency Time 2	s	1800
3	Overfrequency Value 3	p.u.	1.02
	Overfrequency Time 3	s	1800
4	Overfrequency Value 4	p.u.	1.02

	Overfrequency Time 4	s	continuous
5	Overfrequency Value 5	p.u.	1.02
	Overfrequency Time 5	s	continuous
	ROCOF		
	ROCOF limit	Hz/s	2.0
	Applicable Time Frame for ROCOF	s	0.5

Table 5 Grid Code requirements for Frequency Operation Range at PCC.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

WIND FARM:

The frequency operation requirements can be extrapolated from the PCC and be directly applied to the LV terminals of the WTGs. Therefore, the analysis performed for a SGRE platform can be considered equivalent to the compliance analysis of the WF at its PCC if the rest of the equipment at the WF level also withstands this frequency operation range.

5.1.2. Voltage Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Voltage Operation Range can be found in section “REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE GENERACIÓN DE ELECTRICIDAD” of document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value			
	Undervoltage		**Type B/C < 110kV Distribution (2)**	**Type B/C/D < 110kV Transmission (3)**	**Type D ≥ 110kV and < 300 kV Transmission (1)**	**Type D ≥ 300kV and ≤ 400 kV Transmission**
1	Undervoltage Value 1	p.u.	0.85	0.05	0.0	0.0
	Undervoltage Time 1	s	0	0.2	0.15	0.15
2	Undervoltage Value 2	p.u.	0.85	0.85	0.85	0.85
	Undervoltage Time 2	s	1.15	1.5	1.5	1.5
3	Undervoltage Value 3	p.u.	0.85	0.85	0.85	0.85
	Undervoltage Time 3	s	continuous	3600	3600	3600
4	Undervoltage Value 4	p.u.	0.85	0.85	0.9	0.9
	Undervoltage Time 4	s	continuous	continuous	3600	3600
5	Undervoltage Value 5	p.u.	0.85	0.85	0.9	0.9
	Undervoltage Time 5	s	continuous	continuous	continuous	continuous
	Overvoltage					
1	Overvoltage Value 1	p.u.	1.2	1.2	1.2	1.2
	Overvoltage Time 1	s	0	0	0	0.
2	Overvoltage Value 2	p.u.	1.15	1.2	1.2	1.2
	Overvoltage Time 2	s	0.5	0.05	0.05	0.05
3	Overvoltage Value 3	p.u.	1.15	1.15	1.15	1.1
	Overvoltage Time 3	s	1	1	1	1
4	Overvoltage Value 4	p.u.	1.1	1.15	1.15	1.1
	Overvoltage Time 4	s	1	3600	3600	3600

5	Overvoltage Value 5	p.u.	1.1	1.118	1.118	1.0875
	Overvoltage Time 5	s	continuous	3600	3600	3600

Table 6 Grid Code requirements for Voltage Operation Range at PCC.

Remarks:

(1) For voltage operation compliance evaluation is used the worst profile, it is MGE Type D connected to the transmission grid with **≥110kV and < 300 kV**
(2) For WF types B / C connected to the Distribution system, the GC only defines one point for undervoltage condition (<0.85; 1.15 sec), 0.85 is assumed for continuous operation
(3) For WF types B / C connected to transmission system, the operating range is defined as the envelope of the UVRT curve and the continuous operating voltage table

- COMPLIANCE:

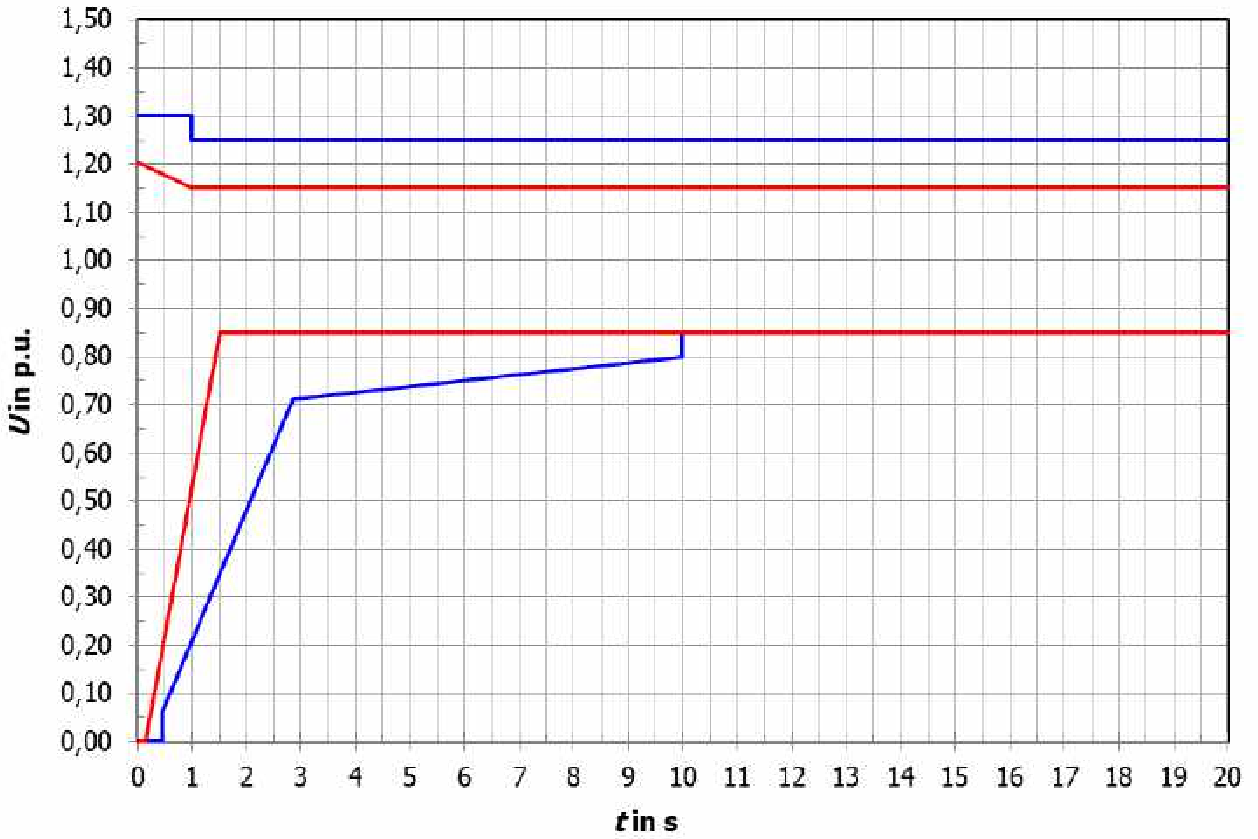
SG5.X-170:

According to the document D3120497 [10], the capability of SG5.X-170 to contribute to the WF compliance of the continuous operation voltage range at rated frequency and rated active power is the following:

Continuous Operation Voltage Range		Maximum Negative Sequence Voltage
Min	Max	
0.95Un	1.12Un	≤5%

Table 7 Continuous operation voltage range of SG5.X-170 at MV terminals.

In addition, they are capable of withstanding symmetrical and asymmetrical faults for any voltage profile within the curves illustrated in Figure 2 without disconnecting.



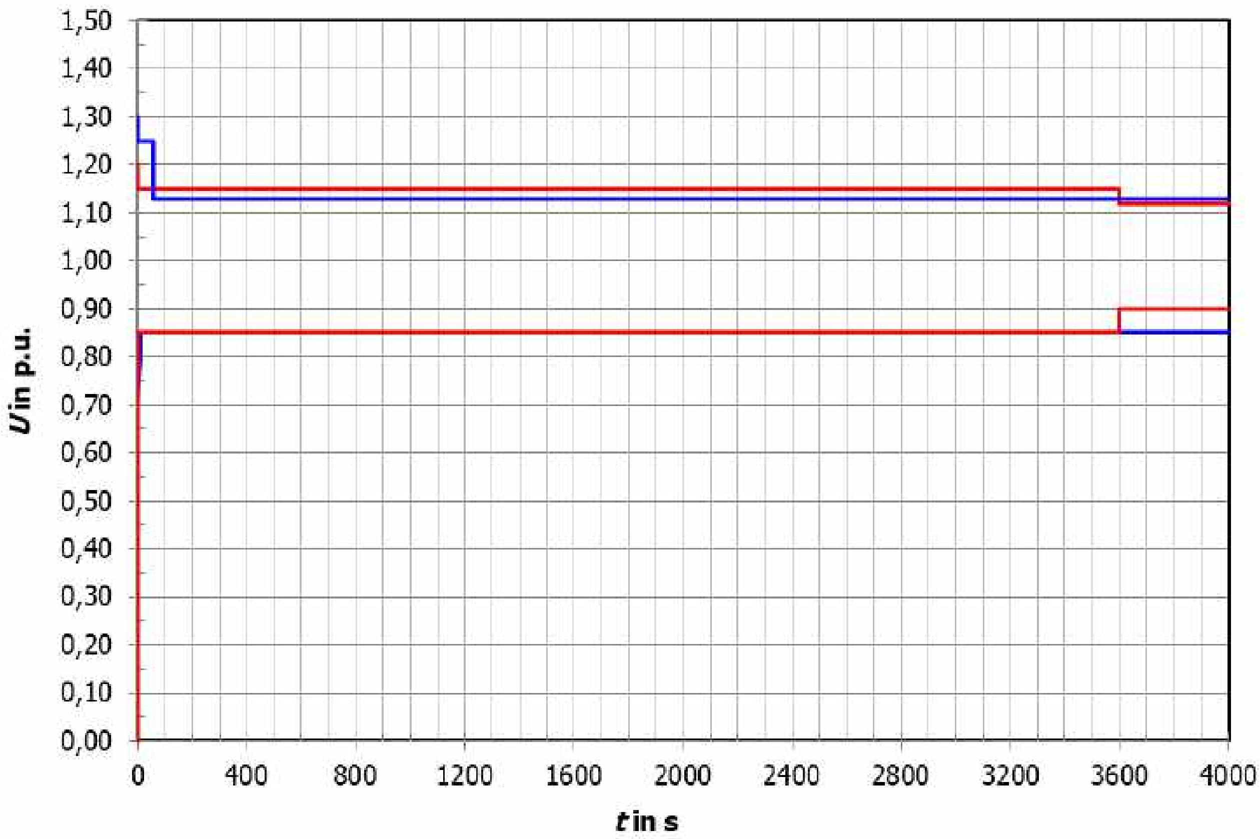


Figure 2. Voltage capability of SG5.X-170 at the **MV terminals** (blue) versus voltage profile required by the Grid Code at the PCC (red).

WIND FARM:

The requirements regarding voltage operation range are specified at the PCC.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the voltage operation range at the WTGs terminals for different operation scenarios of the WF. If this range can be for a certain time beyond the mentioned WTG limits, the WTGs may disconnect.

The complete WF electrical design must be taken into account for these studies, being the following the higher impact elements:

1. On-Load Tap Changer (OLTC): Substations transformers equipped with OLTC are able to decouple the voltage at the PCC with the voltage at the WF collector system.
2. WF collector system impedances: The voltage drop/rise at WTGs terminals across the WF collector system is dependent on this.
3. Reactive power control operation: The reactive power provided by WTGs and other reactive compensation elements causes voltage drop/rise at WTGs terminals. This control is done:
    - In continuous operation by the WF regulator, dispatching setpoints to the different elements.
    - In transient situations by the individual elements.

5.1.3. Voltage/Frequency Operation Area

- REQUIREMENTS:

The Grid Code requirements related with the Voltage/ Frequency Operation Area can be found in section 1.1 “RANGOS DE FRECUENCIA” of document [2].

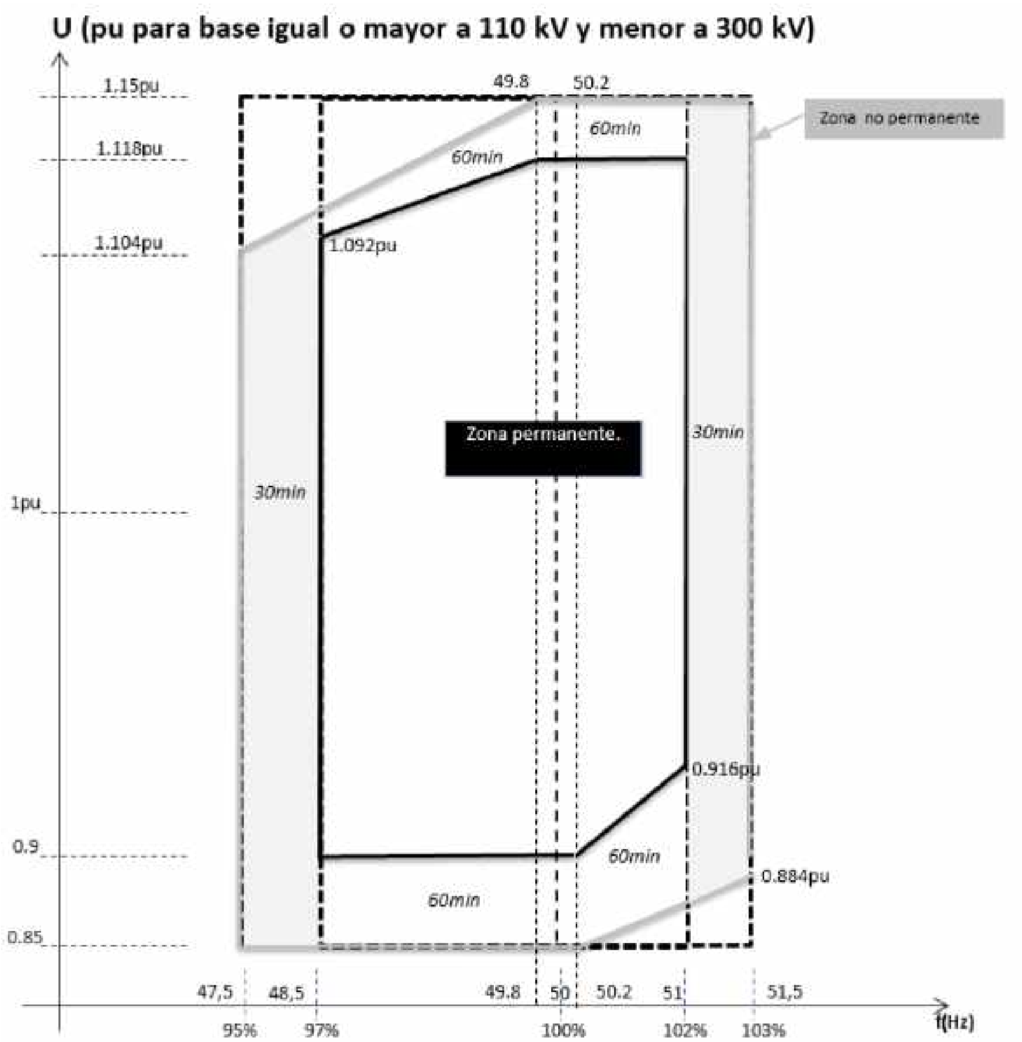


Figure 3. Voltage/Frequency requirements ≥ 110 to <300 kV.

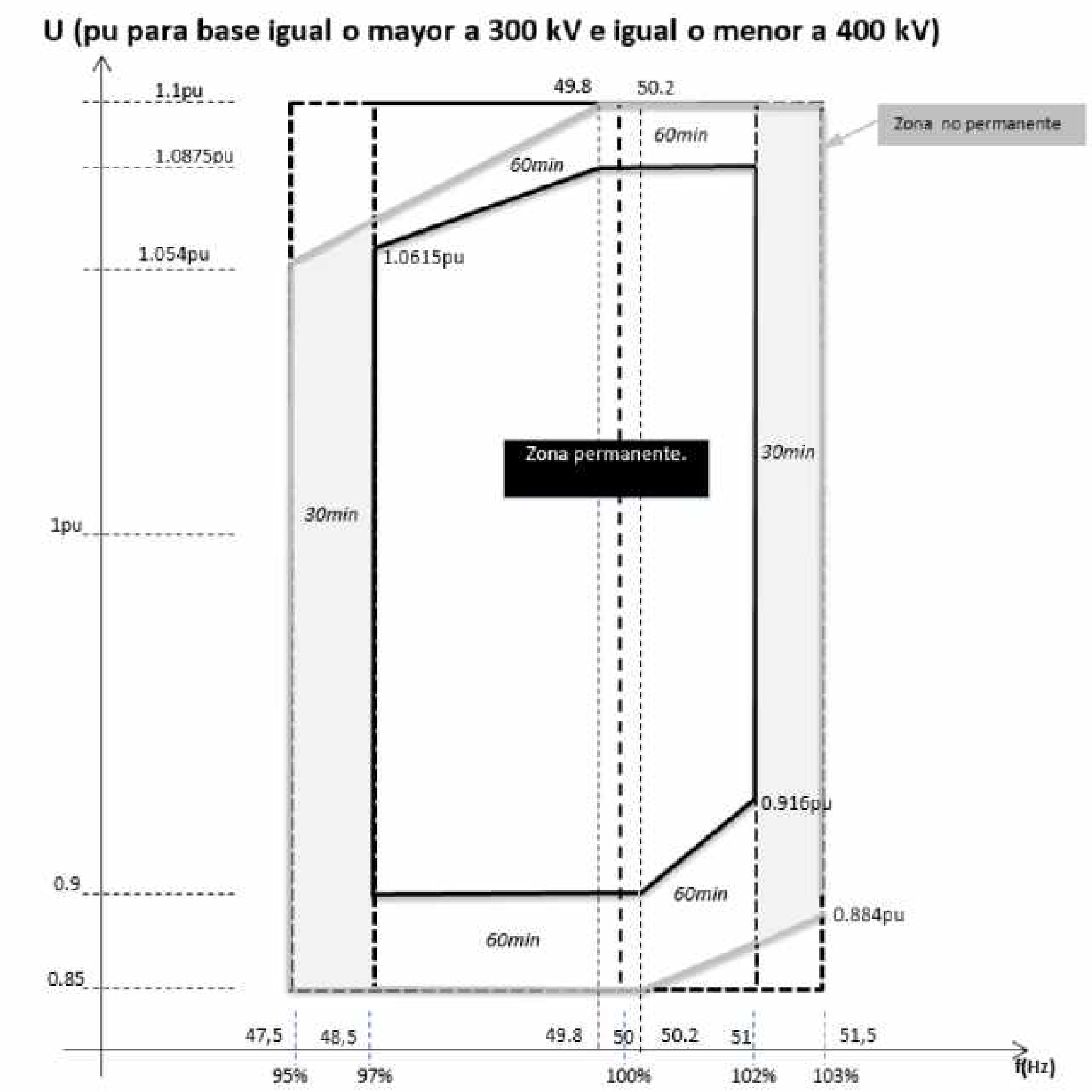


Figure 4. Voltage/Frequency requirements ≥ 300 to <400 kV.

- COMPLIANCE:

SG5.X-170:

The capability of SG5.X-170 WTGs to contribute to the WF compliance of this requirement can be found in D3120497 [10].

WIND FARM:

The requirements regarding voltage/frequency operation range are normally specified at the PCC. Frequency requirements can be extrapolated from the PCC and be directly applied to LV terminals of the WTGs. However, voltage requirements cannot be directly extrapolated to the LV terminals of the WTGs.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the voltage operation range at the WTGs terminals for different operation scenarios of the WF. If this range can be for a certain time beyond the mentioned WTG limits, the WTGs may disconnect.

The complete WF electrical design must be taken into account for these studies, being the following the higher impact elements:

1. On-Load Tap Changer (OLTC): Substations transformers equipped with OLTC are able to decouple the voltage at the PCC with the voltage at the WF collector system.
2. WF collector system impedances: The voltage drop/rise at WTGs terminals across the WF collector system is dependent on this.
3. Reactive power control operation: The reactive power provided by WTGs and other reactive compensation elements causes voltage drop/rise at WTGs terminals. This control is done:
    - In continuous operation by the WF regulator, dispatching setpoints to the different elements.
    - In transient situations by the individual elements.

5.1.4. Reactive Power Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Reactive Power Operation Range can be found in section 2.3.2 “CAPACIDAD DE POTENCIA REACTIVA” of document [2]

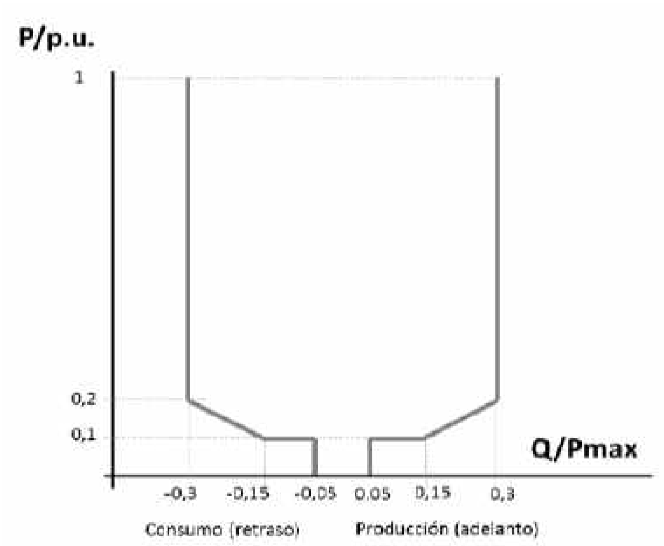


Figure 5. PQ requirements for MGE Type D

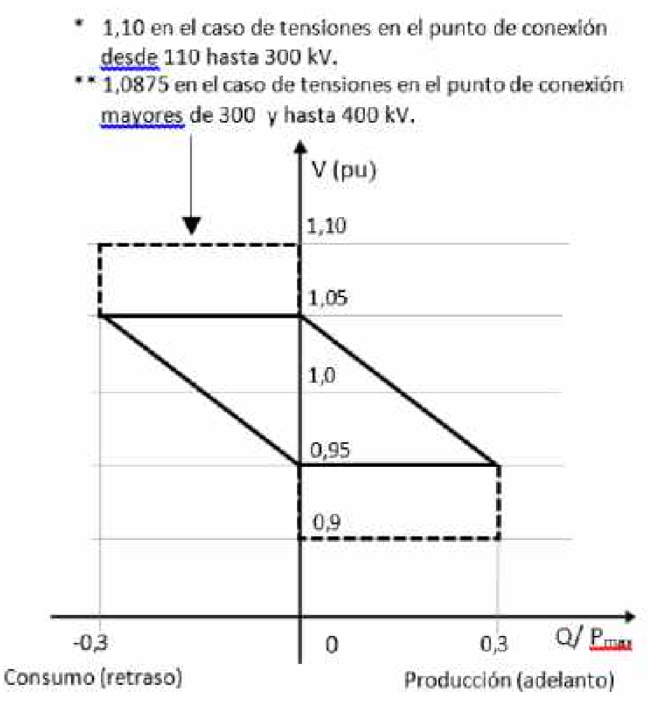


Figure 6. Q-U requirements for MGE Type D.

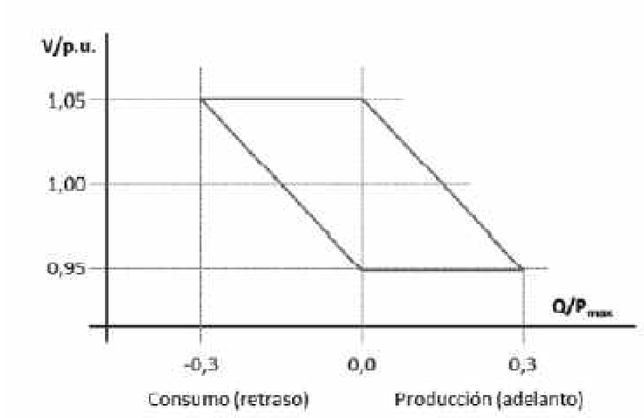


Figure 7. Q-U requirements for MGE Type B or C with Pmax<15MW.

There are particular Grid Code requirements related with the reactive power operation range when the central busbar of the MPE shares the facilities with other MPEs (Cases A and B) and it can be found in section 5.7.3.2 "Procedimiento específico en el caso de existencia de instalaciones compartidas" of document [4]

Case A

In the event that BC of the PGM is located at the HV side of the step-up transformer (LAT) of the PGM, the supplementary simulation shall be carried out considering both the voltage and the reactive power at BC (i.e. LAT in this case) in such a way that it will be necessary to model the collector network from the PGU up to BC, but not the evacuation network up to the NCP

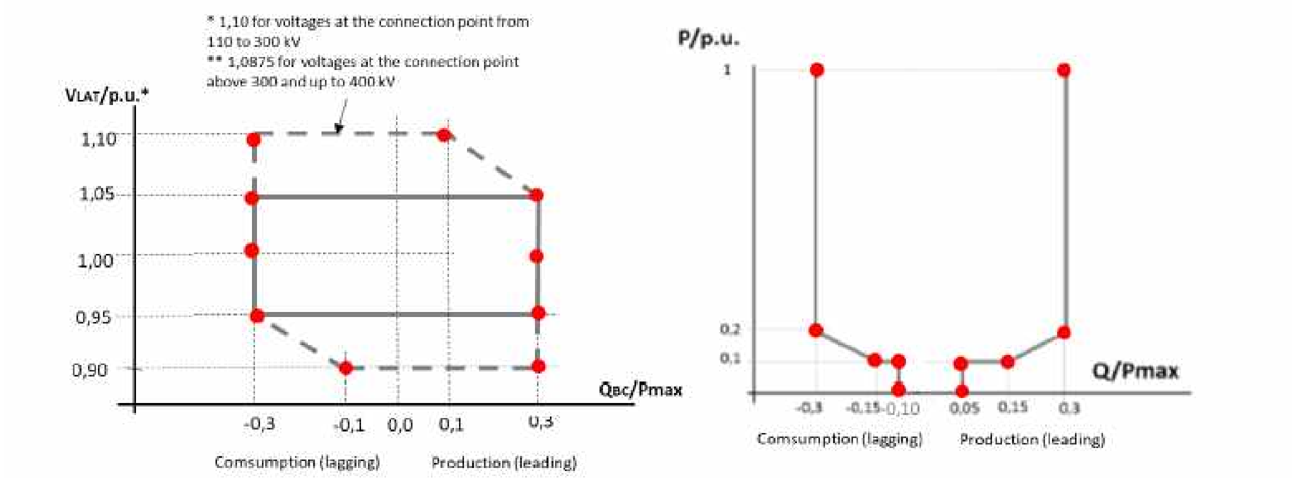


Figure 8. Q-U and PQ requirements for MGE Type D in special Case A

Case B

If the BC of the PGM is located at the LV side of the PGM step-up transformer, the supplementary simulation shall be performed by measuring the reactive power at BC and considering the voltage at the HV side of the shared step-up transformer, so that it will be necessary to model the collector network from the PGU to BC and the shared transformer, but not the rest of the evacuation network up to the NCP

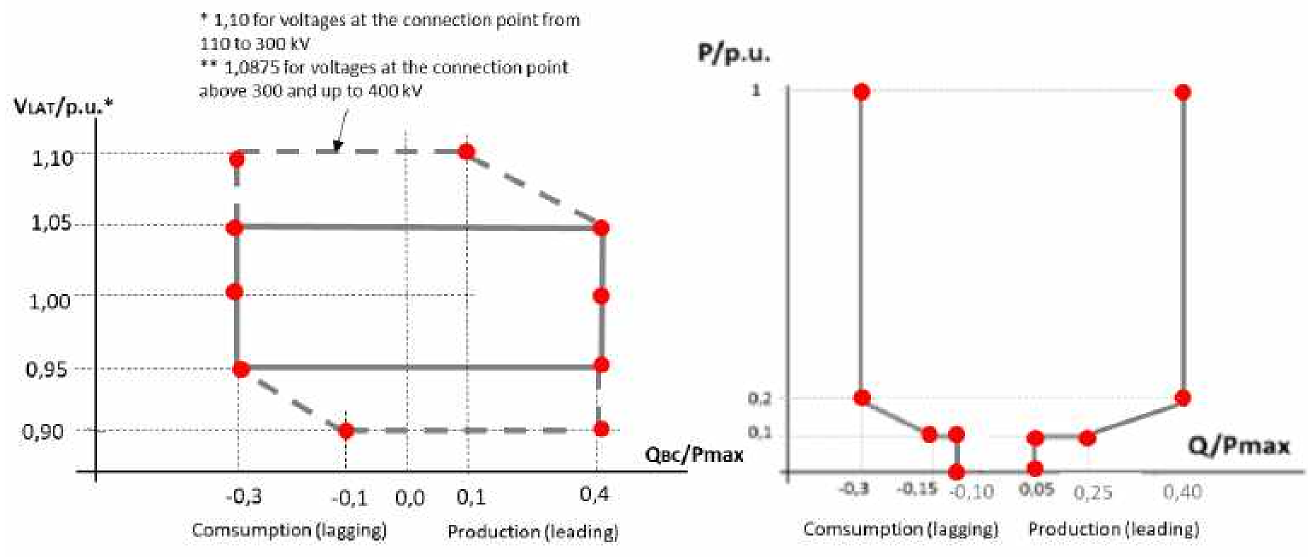


Figure 9. Q-U and PQ requirements for MGE Type D in special Case B

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Type D-C-B		Type Case A		Type Case B	
P (pu)	Q (pu)	P (pu)	Q (pu)	P (pu)	Q (pu)
0.00	-0.05	0	-0.10	0.00	-0.10
0.10	-0.05	0.10	-0.10	0.10	-0.10
0.10	-0.15	0.10	-0.15	0.10	-0.15
0.20	-0.3	0.20	-0.3	0.20	-0.3
1.00	-0.3	1.00	-0.3	1.00	-0.3
1.00	0.3	1.00	0.3	1.00	0.4
0.20	0.3	0.20	0.3	0.2	0.4
0.10	0.15	0.10	0.15	0.10	0.25
0.10	0.05	0.10	0.05	0.10	0.05
0.00	0.05	0.00	0.05	0.00	0.05

Table 8 Grid Code requirements for PQ capability at rated voltage.

Type D ≥ 110 to <300 kV.		Type D ≥ 300 to <400 kV.		Type B / C with Pmax<15MW		Type Case A		Type Case B	
Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)
0.00	0.95	0.00	0.95	0.00	0.95	0.00	0.9	0	0.9
-0.30	1.05	-0.30	1.05	-0.30	1.05	-0.1	0.9	-0.1	0.9
-0.30	1.10	-0.30	1.087	0.00	1.05	-0.3	0.95	-0.3	0.95
0.00	1.10	0.00	1.087	0.30	0.95	-0.3	1	-0.3	1
0.00	1.05	0.00	1.05	0.00	0.95	-0.3	1.05	-0.3	1.05
0.30	0.95	0.30	0.95			-0.3	1.10	-0.3	1.1
0.30	0.90	0.30	0.90			0.1	1.10	0.1	1.1
0.00	0.90	0.00	0.90			0.3	1	0.4	1.05
0.00	0.95	0.00	0.95			0.3	0.95	0.4	0.95
						0.3	0.9	0.4	0.9

Table 9 Grid Code requirements for QU capability at rated voltage.

- COMPLIANCE:

<u>SG5.X-170:</u>

The capability of SG5.X-170 WTGs to contribute to the WF compliance of this requirement can be found in the document D2904942 [11]

<u>WIND FARM:</u>

Considering that the reactive power requirements are specified at the PCC, an electrical study must be carried out by the WF developer in which both the power factor range at the PCC and the voltage deviations at the LV terminals of the WTGs are evaluated. This study would also determine if and to what extent compensation equipment is needed at the WF.

5.2. Fault Ride Through Support

5.2.1. Current Support

- REQUIREMENTS:

The Grid Code requirements related with Fault Ride Through Current Support can be found in section "2.3 REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE PARQUE ELÉCTRICO" of document [2] .

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value
	Current Support	-	Reactive & Active
	Current priority during VRT operation	-	Q priority
	Maximum Required Current Injection/Absorption	p.u.	1.00
	Current Injection/Absorption Calculation Mode	-	Relative Value
	Voltage Calculation Mode	-	Relative Value
	k Factor	-	2 ≤ K ≤ 6 by default = 3.50
	Response Time for Reactive Current Injection/Absorption		
	Tolerance band	+%/-%	-10% of In / +20% of In
	Reaction time	ms	≤ 40 (1)
	Rise time	ms	≤ 50
	Reaction time + Rise time	ms	≤ 50
	Response time	ms	-
	Settling time	ms	≤ 80 (1)
	Overshoot	%	-
	Reactive Current Absorption/Injection during UVRT/OVRT		
1	Voltage Setpoint 1 in p.u.	p.u.	1.30
1	Current Setpoint 1 in p.u.	p.u.	-1.05
2	Voltage Setpoint 2 in p.u.	p.u.	1.10
2	Current Setpoint 2 in p.u.	p.u.	-0.35
3	Voltage Setpoint 3 in p.u.	p.u.	1

	Current Setpoint 3 in p.u.	p.u.	0
4	Voltage Setpoint 4 in p.u.	p.u.	0.9
	Current Setpoint 4 in p.u.	p.u.	0.35
5	Voltage Setpoint 5 in p.u.	p.u.	0.5
	Current Setpoint 5 in p.u.	p.u.	1.75
6	Voltage Setpoint 6 in p.u.	p.u.	0.00
	Current Setpoint 6 in p.u.	p.u.	3.50
	Controlled Asymmetrical Current Injection/Absorption	-	DFIG natural response

Table 10 Grid Code requirements for Current Support.

Remarks:

(1) With regard to the evaluation of these times, if for detecting UVRT condition was used current detection method, up to 20ms are added for the evaluation of these times, in order to determinate the rms value with average values of 20ms.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

WIND FARM:

Usually compliance with this requirement is accepted to be evaluated at WTG terminals. Otherwise, if compliance is demanded at PCC, the WF developer must carry out studies in order to analyze the reactive current support achieved by the WF at the PCC and determine what extra equipment for reactive current support is necessary. Nevertheless, SGRE will cooperate with the WF developer in order to find the correct solution.

5.2.2. Active Power Recovery After Clearance

- REQUIREMENTS:

The Grid Code requirements related with the Active Power Recovery After Clearance can be found in section 3.3 “REQUISITOS DE ROBUSTEZ DE LOS MÓDULOS DE PARQUE ELÉCTRICO” of document [2] and the section 5.11.2.5 “CRITERIOS DE EVALUACIÓN DEL REQUISITO DE RECUPERACIÓN DE LA POTENCIA ACTIVA TRAS EL HUECO DE TENSIÓN” of document [4]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Active Power Level for Recovery Acceptance	%	95.0
Maximum Time for Active Power Recovery	s	1 s for Udip ≥ 0.5Un 2 s for 0.5Un > Udip ≤ 0.2Un 3 s for Udip < 0.2Un
Active Power Recovery Rate after UVRT Mode	pu/s	N/A
Active Power tolerance for settling acceptance	%	5
Maximum time for active power settling	s	3 s for Udip ≥ 0.5Un 4 s for 0.5Un > Udip ≤ 0.2Un 5 s for Udip < 0.2Un
Voltage level for active power recovery	pu	0.85

Table 11 Grid Code requirements for Active Power Recovery After Clearance.

- COMPLIANCE:

<u>SG5.X-170:</u>

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

<u>WIND FARM:</u>

Usually compliance with this requirement is accepted to be evaluated at WTG terminals. Otherwise, if compliance is demanded at PCC, the WF developer must carry out studies in order to analyze the active power recovery achieved by the WF at the PCC and determine what extra equipment for active power support is necessary. Nevertheless, SGRE will cooperate with the WF developer in order to find the correct solution.

5.2.3. Consecutive Voltage Dips

- REQUIREMENTS:

The Grid Code requirements related with the Consecutive Voltage Dips can be found in section 2.3 “REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE PARQUE ELÉCTRICO” of document [2]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Time between Consecutive UVRTs	s	5
Number of Consecutive UVRTs	-	Not defined by GC
Time between series of consecutive UVRTs	s	N/A
Voltage level between consecutive voltage dips	%	Not defined by GC
Energy to be dissipated	Pn*s	WTG capability

Table 12 Grid Code requirements for Consecutive Voltage Dips.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X	D3120497 [10]	✔ Compliance

WIND FARM:

Usually compliance with this requirement is accepted to be evaluated at each individual element of the WF.

5.3. Active Power / Frequency Regulation

- REQUIREMENTS:

The Grid Code requirements related with **Active Power Regulation** can be found in section “1.6. Capacidad y rango de control de la potencia activa” of the document [2].

The Grid Code requirements related with **Frequency Regulation** can be found in section “1. REQUISITOS DE FRECUENCIA” of the d document [2].

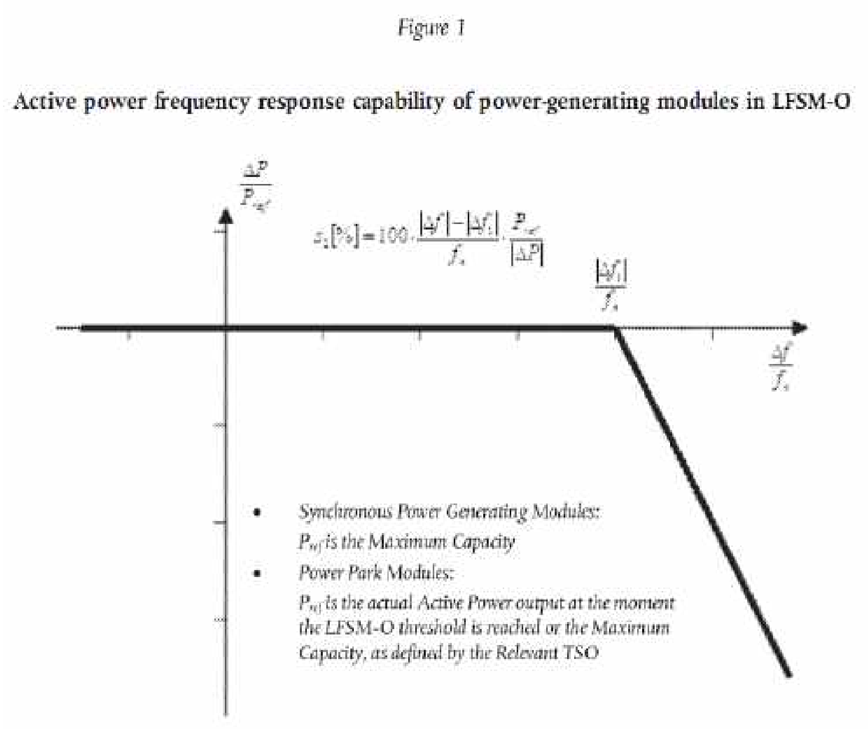


Figure 10 LFSM-O mode [3].

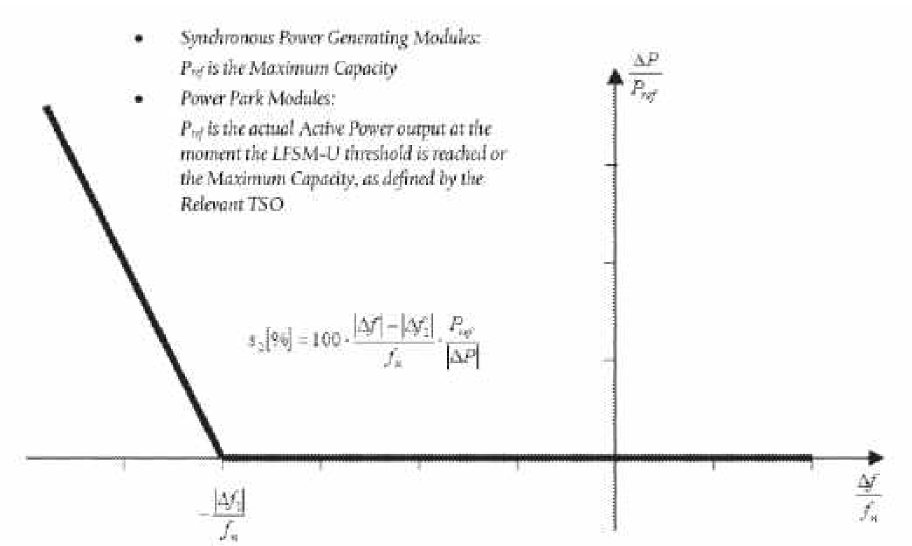


Figure 11 LFSM-U mode [3].

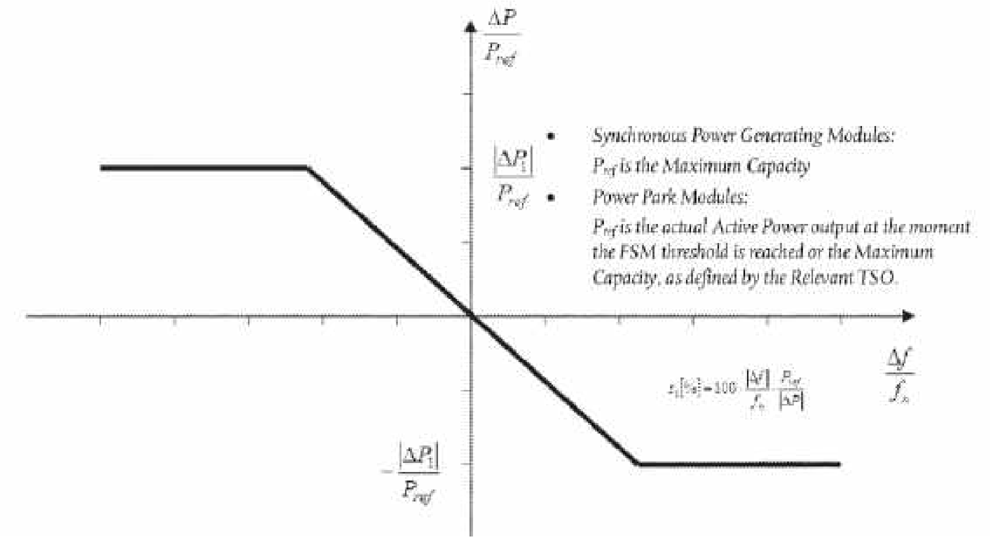


Figure 12 FSM mode [3].

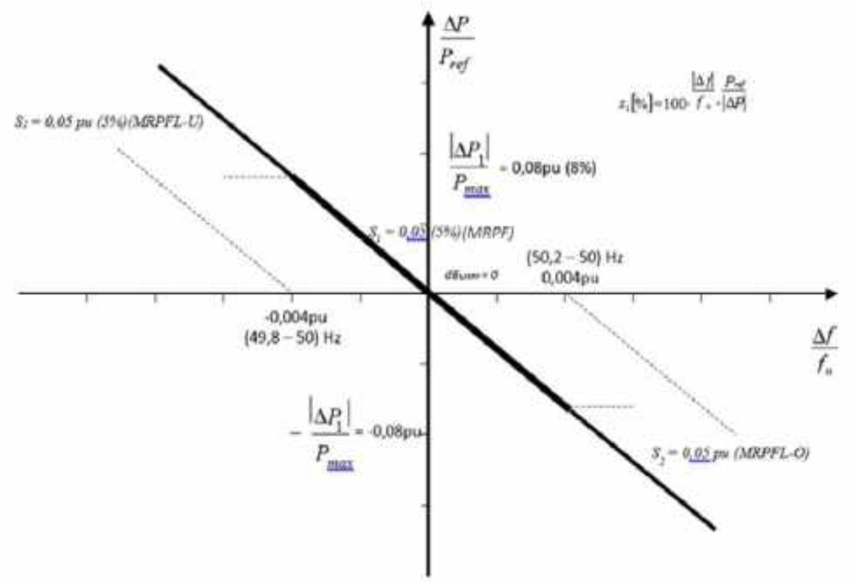


Figure 13 Example of the three modes combined [2].

The Grid Code requirements related with **Active Power Ramp Rates** can be found in section “5.9. Limitación a las rampas de subida y bajada de la potencia” of the document [2].

The Grid Code definition of the **Active Power Regulation Times** can be found in section “1.3” of the document [2]. The SGRE definition of the regulation times is included in the figure below. Note that this SGRE definition matches with the GC.

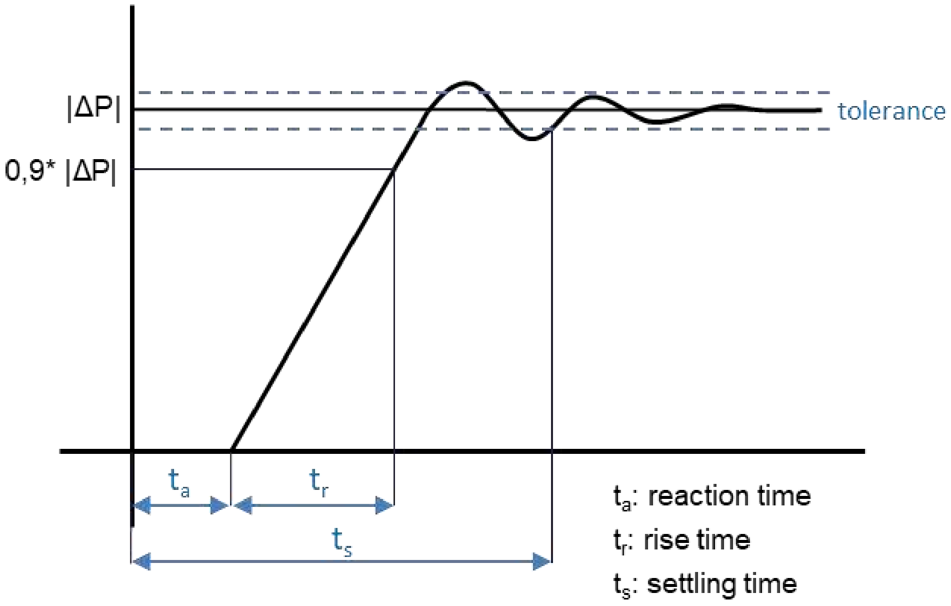


Figure 14 SGRE Definition of the regulation times: ta, tr and ts (te).

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance
WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
ACTIVE POWER REGULATION		AVAILABLE POWER MODE	Not indicated in GC	Not indicated in GC	Not indicated in GC	✔ Compliance
		SPINNING RESERVE / DELTA CONTROL	Not indicated in GC	Not indicated in GC	Not indicated in GC	
	1.6 [2]	CURTAILMENT MODE	Required	Required	Required	✔ Compliance
	5.9 [4]	Curtailment Ramps	-	To be agreed with SO	To be agreed with SO	
	1.6 [2]	Curtailment settling time	Max 3 min	Max 2 min	Max 2 min	
	1.6 [2]	Curtailment Steady state tolerance	±5%Pn	±5%Pn	±5%Pn	
	OTHER:					
		CEASE POWER 5s Required	NA	NA	? To be Clarified (1)	
	1.3, 1.7, 1.8 [2]	FREQUENCY MODE	Required	Required	Required	✔ Compliance

FREQUENCY REGULATION				Frequency Regulation at WTG level	No	No	No	
	1.3, 1.7, 1.8 [2]		ta/tr/ts (ramp down)	≤2s/≤2s/≤20s	≤500ms/ ≤2s/≤20s	≤500ms/ ≤2s/≤20s	To be Clarified (2)	
	1.3, 1.7, 1.8 [2]		ta/tr/ts (ramp up)	≤2s/≤5s/≤30s	≤500ms/ ≤5s/≤30s	≤500ms/ ≤5s/≤30s	To be Clarified (2)	
	1.3, 1.7, 1.8 [2]		Steady state tolerance freq. regulation	±5%ΔP	±5%ΔP	±5%ΔP	(3)	
	1.8 [2]	Secondary Frequency regulation	??	??	??	To be Clarified (4)		
	5.4 [4]	Frequency Restoration	??	??	??	To be Clarified (5)		
	-	Enhanced Frequency Ramps needed		Yes	Yes	Yes	To be Clarified (2)	
	OTHER:							

Table 13 Grid Code requirements for Active Power / Frequency Regulation.

Remarks:

(1) A steady state tolerance expressed as % of ΔP could imply a very demanding band for low power increase values. Therefore, ideally the tolerance shall be expressed as % of the rated power.
(2) Read aspects to clarify section 6.1 in this GCA.
(3) Read aspects to clarify section 0 in this GCA

According to the SGRE interpretation of the GC, the key frequency regulation parameters are summarized in the following table:

Mode	[Doc] Section	Parameter	Type B	Type C	Type D
LFSM-O	1.3 [2]	LFSM-O frequency threshold	50,2 Hz	50,2 Hz	50,2 Hz
	1.3 [2]	LFSM-O Droop setting	5%	5%	5%
	5.1 [4]	LFSM-O definition of Pref	Pnom	Pnom	Pnom
		Behavior of the PGM once the regulating minimum level is reached	Not defined	Not defined	Not defined

LFSM - U	1.7 [2]	LFSM-U frequency threshold	NA	49.8 Hz	49.8 Hz
	1.7 [2]	Droop setting	NA	5%	5%
	5.2 [4]	LFSM-U definition of Pref	NA	Pnom	Pnom
FSM	1.8 [2]	|ΔP|/Pref	NA	8%	8%
	1.8 [2]	frequency response insensitivity	NA	= 10 mHz	= 10 mHz
	1.8 [2]	FSM deadband	NA	0 mHz	0 mHz
	1.8 [2]	FSM droop (up)	NA	5%	5%
	1.8 [2]	FSM droop (down)	NA	5%	5%
	5.3 [4]	FSM definition of Pref	NA	Pnom	Pnom
	1.8 [2]	t1 maximum admissible initial delay for PGMs without inertia	NA	500 ms	500 ms
	1.8 [2]	t2 maximum admissible full activation time	NA	30 s	30 s
	1.8 [2]	time period for the provision of full active power frequency response	NA	15 min	15 min

Table 14 Grid Code requirements for Regulation Parameters.

- COMPLIANCE:

SG5.X-170:

According to the document D3120497 [10], SG5.X-170 WTGs could comply with the required active power ramp rates.

Time responses required in frequency regulation (tr) makes that fast frequency ramps are required in order to provide fast frequency regulation active power ramps (22.5%Pn/s when decreasing power and 3.6%Pn/s when increasing power). SGRE SG5.X-170 could comply with this requirement but SW logics are pending to implement in serial SW

WIND FARM:

SGRE PPC cannot comply with all the requirements. The requirements related with the MRPF highlighted in section 6.1 of this GCA and the references to Frequency restoration in section 0 must be clarified.

5.4. Reactive Power / Voltage Regulation

- REQUIREMENTS:

The Grid Code requirements related with the Reactive Power/Voltage Regulation can be found in section "2.3.3 Modos de control de potencia reactiva" of the document [2].

Additional requirements about reactive power regulation time response times found in the following section "2.3.2.1. Módulos de parque eléctrico tipo D" of document [2].

The SGRE definition of the regulation times is included in the figure below. Note that this SGRE definition does not match with the GC. Therefore, the GC regulation times have been adapted to SGRE definition in this GCA.

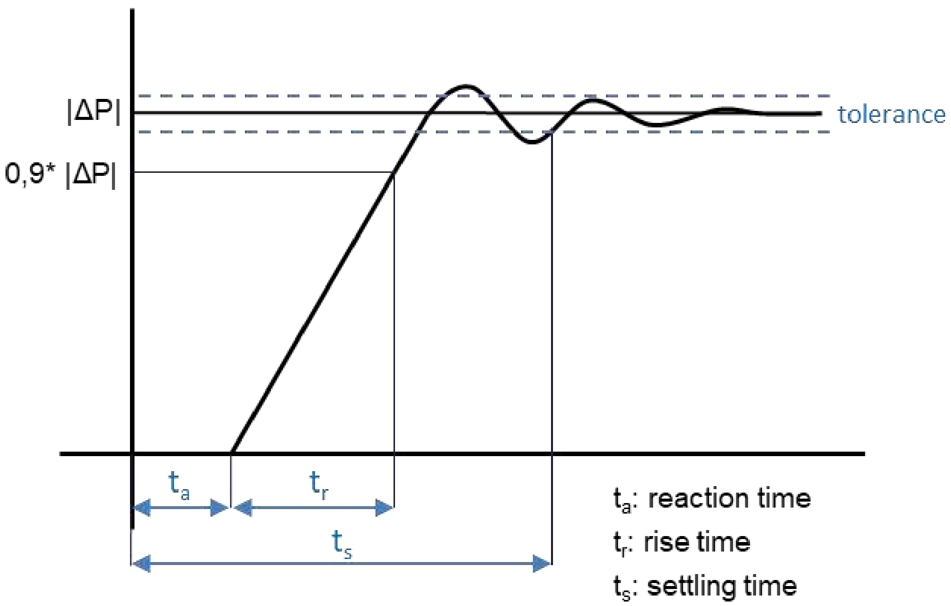


Figure 15 SGRE Definition of the regulation times: ta, tr and ts (te).

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance
WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
	21.3.d.i [3]	5.2 COSPHI MODE (POWER FACTOR)	Required	Required	Required	✔ Compliance (1)
	5.8.2.3 [4]	(COSPHI) ta/tr/ts	…/…/60s	…/…/60s	…/…/60s	
	5.8.2.3 [4]	(COSPHI) Steady state tolerance	Q= ±1.5%Pmax	Q= ±1.5%Pmax	Q= ±1.5%Pmax	

	21.3.d.i [3]	5.3 REACTIVE POWER MODE (Q)	Required	Required	Required	✔ Compliance (1)
	5.8.2.3 [4]	(MODE Q) ta/tr/ts	…/…/60s	…/…/60s	…/…/60s	
	5.8.2.3 [4]	(MODE Q) Steady state tolerance	Q= ±1.5%Pmax	Q= ±1.5%Pmax	Q= ±1.5%Pmax	
		5.4 DIRECT VOLTAGE MODE (V)	NA	NA	NA	
	2.3.3 [2]	5.5 REACTIVE POWER / VOLTAGE MODE (Q/V)	Required	Required	Required	✔ Compliance (1)
	2.3.3 [2]	(Q/V) curve defined by slope	Required	Required	Required	
	2.3.3 [2]	(Q/V) ta/tr/ts	ta+tr=1s ts= 5s	ta+tr=1s ts= 5s	ta+tr=1s ts= 5s	(2)
		AVAILABLE REACTIVE POWER AT PCC CALCULATION	NA	NA	NA	
	OTHER:					

Table 15 Grid Code Requirements for Reactive Power / Voltage Regulation.

Remarks:

(1) It must be agreed with client/SO the mode of operation of the reactive power/voltage control and its final parameter settings.

According to the SGRE interpretation of the GC, the key voltage regulation parameters are summarized in the following table:

Mode	[Doc] Section	Parameter	Type B	Type C	Type D
Q/V curve defined by slope		Slope (droop)	2%	2%	2%
		Slope resolution	Not defined	Not defined	Not defined
		Deadband	0 p.u.	0 p.u.	0 p.u.
		Deadband resolution	Not defined	Not defined	Not defined

		Vmin/Vn	Not defined	Not defined	Not defined
		Vmax/Vn	Not defined	Not defined	Not defined
		Qmin	Not defined	Not defined	Not defined
		Qmax	Not defined	Not defined	Not defined
Q/V curve defined by points		[Q_1; P_1]	NA	NA	NA
		[Q_2; P_2]	NA	NA	NA
		[Q_3; P_3]	NA	NA	NA
		[Q_4; P_4]	NA	NA	NA
		[Q_5; P_5]	NA	NA	NA

Table 16 Grid Code requirements for Regulation Parameters.

- COMPLIANCE:

<u>SG5.X-170:</u>

According to the document D3120497 [10], SG5.X-170 WTGs can comply with the required reactive power ramp rates.

<u>WIND FARM:</u>

SGRE PPC can comply with all the requirements.

5.5. Power Quality

- REQUIREMENTS:

No specific requirements for power quality have been found in the main document of the Grid Code [2]. It is important to highlight that even there is not a requirement in the Grid Code, SGRE will expect that the TSO will ask for some power quality measurements, such as asked in the Annex I “Contenido de la base de datos estructural del operador del Sistema” of the document “P.O. 9 Información intercambiada por el operador del Sistema” [5]

Remarks:

The GC requires voltage harmonic measures. These measures are outside of IEC 61000-21 scope. Therefore, it needs to consider voltage harmonic measures and current harmonic measures and should be to consider into account in the offer

- COMPLIANCE:

The WF developer may perform a power quality study to gain some certainty on the WF fulfilment of these requirements, and SGRE can provide WTG power quality reports or harmonic models for this purpose, but the recommendation is to only evaluate this once real WF measurements are available so effective solutions can be properly designed.

5.6. Communications

- REQUIREMENTS:

The Grid Code requirements related with the Communications can be found in section "5.1 Intercambio de información" of the document [2]

"5.1 Intercambio de información.

Para los módulos de generación de electricidad de tipo A, B, C o D será de aplicación lo recogido en el procedimiento de operación que regule la información intercambiada por el operador del sistema y, en todo caso, en la normativa que al respecto sea aprobada para el intercambio de información con los gestores de la red."

More signal requirements regarding MRPF mode can be found on section "1.8. Modo de regulación potencia-frecuencia (MRPF)" of the document [2].

"Adicionalmente a lo especificado en cuanto a la monitorización en tiempo real del MRPF en el Reglamento (UE) 2016/631, de 14 de abril de 2016, el módulo de generación de electricidad estará capacitado para recibir en tiempo real del operador del sistema e implementar consignas de potencia en reserva a subir y a bajar mínimas garantizadas, que podrían ser diferentes. En el caso de módulos de parque eléctrico, las consignas de banda a subir y bajar se respetarán en la cuantía que permita la diferencia entre el recurso primario disponible y el nivel mínimo de regulación."

In addition, the RfG 2016/631 [3] stablishes for the MRPF mode the below requirements, as it's indicated in the paragraph above:

"Section 15.2 g) [Applies to MPE. Type C and Type D]

En cuanto a la monitorización en tiempo real del MRPF:

i) para monitorizar el funcionamiento de la respuesta frecuencia-potencia, la interfaz de comunicación deberá estar equipada para transferir en tiempo real y de forma segura desde la instalación de generación de electricidad hasta el centro de control de la red del gestor de red pertinente o del GRT pertinente, a instancias del gestor de red pertinente o del GRT pertinente, al menos las señales siguientes:

señal de estado del MRPF (activado/desactivado);
salida de potencia activa programada;
valor efectivo de la salida de potencia activa;
ajuste efectivo de los parámetros de respuesta de la potencia activa con la variación de frecuencia;
estatismo y banda muerta;

ii) el gestor de red pertinente y el GRT pertinente deberán especificar las señales adicionales que deberá proporcionar la instalación de generación de electricidad por los dispositivos de monitorización y registro con el fin de verificar el funcionamiento del suministro de reservas de regulación frecuencia-potencia por parte de los módulos de generación de electricidad participantes."

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance

WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
COMMUNICATIONS		Hardwired signals required	Not defined	Not defined	Not defined	? To be Clarified (1)
		Signal list defined in the GC	Not defined	Not defined	Not defined	? To be Clarified (1)
		External communication protocols defined in the GC for SGRE SCADA	Not defined	Not defined	Not defined	? To be Clarified (1)

Remarks:

(1) The signal types and the communication protocols are not defined, so the project's specific signal list and communications architecture must be negotiated with the TSO and WF developer during the connection conditions agreement.

- COMPLIANCE:

WIND FARM:

SGRE CSSS/PPC has different communications protocols, installed and tested, to access third party data, such as the substation or the weather mast, and/or to permit third parties to access wind farm data without requiring additional development. These protocols are mainly OPC-UA, and IEC 60870-5-104.

The following topics must be considered:

- Communication with the System Operator will have to be performed by the Wind Farm Developer through a Substation RTU. The SGRE SCADA system can communicate with the RTU installed in the substation by using one of the protocols mentioned above (preferably IEC 60870-5-104 protocol).
- Signals of the substation devices, such as transformer taps, switchgears, connection breakers, etc. can be integrated in the SGRE SCADA system provided. These are included in the substation integration through the RTU by using IEC 60870-5-104 protocol.
- Signals referred to the WTGs can be provided by the SGRE SCADA system to the Substation RTU by using IEC 60870-5-104 protocol.
- The installation of a met mast should be considered by the WF developer. The signals of the met mast can be integrated in the SGRE SCADA system. The communication protocol for this has not been defined at the time of preparation of this document.

Anyway, the final signal types and the communication protocols are not defined, so the project's specific signal list and communications architecture must be negotiated with the TSO/DSO and WF developer during the connection conditions agreement.

5.7. Protections

- REQUIREMENTS:

The Grid Code requirements related with the Protections can be found in Annex I "Contenido de la base de datos estructural del operador del Sistema" of the document "P.O. 9 Información intercambiada por el operador del Sistema" of the document [5]

"1.2.5.2 Protecciones asociadas a cada unidad generadora (aerogenerador, inversor, etc.).

• Relé de mínima tensión: indicar fases en que mide y ajustes.

• Relé de sobretensión: ajustes.

• Protección de mínima frecuencia: ajustes y cumplimiento del procedimiento por el que se establecen los Planes de Seguridad.

• Protección de sobrefrecuencia. Ajustes.

• Dispositivos automáticos de reposición por frecuencia: Confirmar que no existen o que están deshabilitados.

• Disparo por sobrevelocidad, en su caso. Valor de disparo."

Therefore, the Grid Code as defining the information regarding the WTG protections: **undervoltage, overvoltage, underfrequency, overfrequency and overspeed.**

- COMPLIANCE:

<u>SG 5.X-170:</u>

According to document D3120497 and D2314253 SG 5 X can comply with this requirement.

5.8. Electrical Simulation Models

- REQUIREMENTS:

The Grid Code requirements related with the electrical simulation models can be found in section 5.2 "MODELOS DE SIMULACIÓN" of the document [2].

Furthermore, the following documents define requirements about the electrical models:

- Section "6. Validación del modelo de Simulación" of the document [4]
- Annex I "Contenido de la base de datos estructural del operador del Sistema", section 1.4 "Datos necesarios para la realización de estudios dinámicos" of the document [5]
- "Condiciones de validación y aceptación de los modelos" [6]
- "Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red" [7]

According to the SGRE interpretation of the GC, the models required are summarized in the following table:

Item	Value
RMS Model	
WTG RMS model	YES
WFC RMS model	YES
RMS model software	PSS/E and DigSilent (1)
WTG RMS Model validation	YES
WFC RMS Model validation	YES
RMS Model validation standard	Yes Based on section 6 of document [4] and document [6]
Library Model	
WTG Library Model	YES
WFC Library Model	YES
Library models standards	N/A
EMT Model	

WTG EMT model	YES, Based on section 6 of document [4]
WFC EMT model	YES, Based on section 6 of document [4]
EMT model software	N/A
WTG EMT Model validation	N/A
WFC EMT Model validation	N/A
EMT Model validation standard	N/A
Harmonic Model	
WTG Harmonic model	NO

Table 17 Grid Code required models.

- COMPLIANCE:

The availability of an electrical simulation model for a specific WTG configuration and WFC, in the requested simulation SW (PSS/E, DigSilent, library model parameters) and for a specific purpose (RMS and EMT) can be requested to SGRE. However, the following tables shows validation status:

Item	Value WTG	
Platform	Validation Status according to REE (P.O.9)	Certificated according to NTS
SG 5.X-170	Pending	Pending

Item	Value WFR	
Platform	Validation Status according to REE (P.O.9)	Certificated according to NTS
PMUA	Pending	OK

Remarks:

(1) Grid operator (REE) request PSSe model based on reference [6] and [7] but for running simulations requested in NTS v2.1 [4] any model RMS/EMTvalidated is accepted

5.9. WF Simulation/Test/Certification

- REQUIREMENTS:

The Grid Code requirements related with the simulation/test/certification can be found in section 4.1. “ASPECTOS GENERALES” of the document [4]

According to the SGRE interpretation of the GC, the requirements are summarized in the following table:

Item	WF Simulation Required	WF Test Required	WTG Certification Required	WFC Certification Required	WF Certification Required	Models included in Certification (2)
Frequency range	No	No	No	No	No	No
Voltage range	No	No	No	No	No	No
Fault Ride Through - UVRT	Yes	No	Yes	No	No	Yes
Fault Ride Through - OVRT	No	No	No	No	No	No
Reactive power capability	Yes	No	Yes	No	No	Yes
Fault current support	Yes	No	Yes	No	No	Yes
Post fault active power recovery	Yes	No	Yes	No	No	Yes
Active power control	No	Yes*	No	Yes	No	No
Frequency control	No	Yes*	No	Yes	No	No
Frequency restoration	No	To be clarified (1)	No	No	No	No
Power factor control	Yes	Yes*	No	Yes	No	No
Reactive power control	Yes	Yes*	No	Yes	No	No
Voltage control	Yes	Yes*	No	Yes	No	No
Power Quality	No	No	No	No	No	No
Inertia Emulation (optional)	Yes	No	No	No	No	No
Power Oscillations Damping	Yes	No	Yes	Yes	No	No

Table 18 Grid Code required Simulation / Test / Certification.

*On site tests may not be required if certification is available.

- COMPLIANCE:

SG5.X-170:

Information under request on SG5.X-170 WTGs capabilities can be provided to support WF simulations or test.

The required WTG certificate is not yet available for SG5.X-170.

WIND FARM:

Information under request on PPC capabilities can be provided to support WF simulations or test.

The required WFC (PMUA) certificate is already available for PPC.

5.10. Special Requirements

5.10.1. Phase Jump

- REQUIREMENTS:

The Grid Code requirements related with the capability of withstanding a phase jump, can be found in section 3.3.2 "CAPACIDAD PARA SOPORTAR SALTOS ANGULARES" of the document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Maximum Phase Jump	º	20

Table 19 Grid Code requirements for Phase Jump.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

5.10.2. Inertia Emulation

- REQUIREMENTS:

The Grid Code requirements related with the provision of Inertia Emulation, can be found in section 1.9 " EMULACIÓN DE INERCIA" of the document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Applicability of Inertia Emulation requirement	-	Optional (2)
Minimum Required Duration for Additional Active Power - $t_{\Delta P}$	s	8
Minimum Additional Active Power – ΔP	%	10%
Reference for Additional Active Power	-	Prated
Additional active power proportional to frequency deviation	% / Hz	N/A
Additional active power proportional to ROCOF	% / (Hz/s)	N/A
Activation by frequency / ROCOF	-	ROCOF
Frequency activation threshold	Hz	N/A
ROCOF activation threshold	Hz/s	±0.5
Maximum reaction time	s	N/A
Maximum response time - $t_{response}$	s	0.15
Maximum overshoot	%	N/A
Deactivation by frequency / ROCOF	-	Frequency
Frequency deactivation threshold	Hz	±0.5
ROCOF deactivation threshold	Hz/s	N/A
Maximum downwards active power ramp rate	% / s	N/A
Max. Subsequent Power Drop below Pre-disturbance - ΔP_{drop}	%	N/A
Max recovery time between consecutive inertia responses - $t_{recovery}$	s	N/A
Minimum Active Power for Inertia Response Availability - P_{min}	pu	N/A

Table 20 Grid Code requirements for Inertia Emulation.

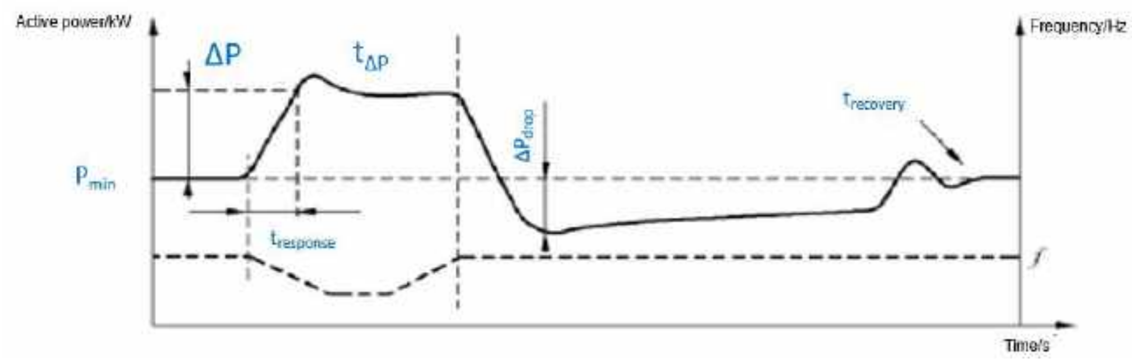


Figure 16 Example of the inertia emulation behavior.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D2097474 [12]	✕ Non-compliance(1)

WIND FARM:

SGRE PPC is used to operate the Inertial response and enables SGRE Wind Turbines to provide an overproduction of active power. SGRE PPC cannot comply with all the requirements.

5.10.3. Power Oscillations Damping (POD)

- REQUIREMENTS:

The Grid Code requirements related with the provision of a Power Oscillations Damping (POD) system can be found in section 2.3.5 “AMORTIGUAMIENTO DE LAS OSCILACIONES DE POTENCIA” of the document [2] and section 5.10 “AMORTIGUAMIENTO DE LAS OSCILACIONES DE POTENCIA EN MPE” of document [4]

5.10.3.1. Acceptance criteria for analysis based on eigenvalues

The criterion for the assessment of the study described in the subsection shall consider that the PPM does not adversely contribute to the damping of oscillation modes between 0.1 Hz and 1.5 Hz if the following conditions are met:

• *The introduction of a PPM in node 1 does not introduce new oscillation modes with a damping of less than 5%.*

• *Under no circumstances will existing modes reduce their damping below 5%.*

- COMPLIANCE:

<u>SG 5.X-170:</u>

SGRE can prepare the models and reports required by TSO according to NTSV2.1 to show compliance with the requirement

5.10.4. System Strength

- REQUIREMENTS:

The Grid Code doesn't define a minimum System Strength value (short circuit value-SCR), however, in section "Disposición adicional segunda. Valor de los parámetros, porcentajes y ratios contenido en los anexos." of the document [9] defines a SCR value

"Para los nudos con módulos de parque eléctrico existentes o con permisos de acceso concedidos, que no cumplen con el Reglamento (UE) 2016/631 de la Comisión, de 14 de abril de 2016, se fija en 10 el valor mínimo del parámetro WSCR al que se refiere el apartado 4 del anexo I. Para el resto de nudos, dicho valor se fija en 6."

In English:

"For electrical nodes with power park modules under operation or with access permits guaranteed, that do not comply with Regulation (EU) 2016/631 of the Commission, of April 14, 2016, the minimum value of Weighted Short Circuit Ratio (WSCR) will be 10 based on section 4 of annex I. For the rest of electrical nodes, ***this value will be 6****."*"

- COMPLIANCE:

<u>SG5.X-170:</u>

According to document D3120497 [10], the capability of SG5.X-170 to contribute to the WF compliance of this requirement is the following:

Parameter	Value
Min. SCR at WTG MV Terminals **V-Direct operation**	2 **2 > SCR > 1.5**
Min. SCR at WTG MV Terminals **Q-Direct operation**	3 **3 > SCR > 1.5**
Min X/R at WTG MV Terminals **V-Direct operation** **Q-Direct operation**	**3**

Table 21 Standard minimum interconnection electrical characteristics for SG5.X-170.

<u>WIND FARM:</u>

The requirements regarding short circuit ratio (SCR) are specified at the PCC.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the SCR at the WTGs terminals for different operation scenarios of the WF.

5.10.5. Reconnection Blockage / Synchronization to the Grid

- REQUIREMENTS:

The Grid Code requirements related with the Reconnection Blockage can be found in section "CAPACIDAD TÉCNICA DE RECONEXIÓN TRAS PERTURBACIÓN" of the document [2]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Minimum reconnection voltage	p.u	0.9
Maximum reconnection voltage	p.u.	>220 kV - 1.118 < 220 kV -1.1
Minimum reconnection frequency	Hz	47.5
Maximum reconnection frequency	Hz	51.5
Reconnection observation time for the voltage	Sec	Not defined
Reconnection observation time for the frequency	Sec	Not defined
Other reconnection measurement variable	-	N/A
Reconnection based on WF/WTG measurement	-	WF/WTG

Table 22 Grid Code requirements for Reconnection Blockage.

- COMPLIANCE:

The blockage of the automatic reconnection as a function of the grid voltage or frequency is implemented by SGRE at WTG level. If the Grid Operator requests this function at PCC level, it shall be clarified if the SGRE function at WTG level is accepted by the Operator.

6. Aspects to Clarify

6.1. Active Power/Frequency regulation

The following requirement in the MRPF section 1.8 of document [2] requires clarification:

"1.8. Modo de regulación potencia-frecuencia (MRPF)

(…)

Adicionalmente a lo especificado en cuanto a la monitorización en tiempo real del MRPF en el Reglamento (UE) 2016/631, el módulo de generación de electricidad estará capacitado para recibir en tiempo real del operador del sistema e implementar consignas de potencia en reserva a subir y a bajar mínimas garantizadas, que podrían ser diferentes. En el caso de módulos de parque eléctrico, las consignas de banda a subir y bajar se respetarán en la cuantía que permita la diferencia entre el recurso primario disponible y el nivel mínimo de regulación."

The wording of this requirement is not clear. Since it is in the MRPF section, SGRE understands that the "reserves" mentioned are in fact the "|ΔP1|/Pmax" parameters of the MRPF mode (read screenshot from [2] below) which are available in the SGRE regulation tool. However, note that these parameters are not power reserves but power ranges of operation of the MRPF mode. Moreover, the requirement indicates that these reserves shall be "guaranteed", however, note that a WFs depends on a variable energy source so the SO shall define how they expect a WF to response.

1.8 Modo de regulación potencia-frecuencia (MRPF). En relación con el modo de regulación potencia-frecuencia (MRPF), los módulos de generación de electricidad de tipo C o D deberán ser capaces de activar el suministro de reservas de regulación potencia-frecuencia, de acuerdo con lo especificado a este respecto en el Reglamento (UE) 2016/631, de 14 de abril de 2016. A este respecto, las características estáticas de las respuestas de los modos MRPFL-O y MRPFL-U se acumulan, en su caso, a la característica estática de la respuesta de este modo MRPF.

Salvo indicación en contra del operador del sistema, los parámetros ajustables del MRPF serán los siguientes:

a) Intervalo de potencia activa en relación con la capacidad máxima $|\Delta P_1|/P_{max}$ igual al 8 %.
b) Insensibilidad de respuesta con la variación de frecuencia $|\Delta f_1|$ igual al 10 mHz.
c) Banda muerta de respuesta con la variación de frecuencia igual al 0 mHz.
d) Estatismo s_1 igual al 5 %.

A confirmation of SGRE interpretation of the requirement is necessary. It is important to remark that in case that the SO states SGRE interpretation is not accurate, the requirements shall be analyzed in order to assure compliance.

6.2. Frequency Restoration

The following test referenced in the NTS [4] appears to be related with the frequency restoration, however, it is not clearly defined. **It shall be clarified if this test applies to WFs and if it does, the test procedure and the technical requirements shall be defined by the SO.**

REQUISITO				FORMA DE EVALUACIÓN	
Artículo [1]	Definición del Requisito	Tipo MGE	Subapartado de la Norma Técnica	MPE	MGES
13.2	Modo regulación potencia-frecuencia limitado-sobrefrecuencia (MRPFL-O)	≥A	5.1	(S y P) o C**	(S y P) o C**
15.2.(a) y (b)	Capacidad de control y el rango de control de la potencia activa en remoto	≥C	5.5	P o C	N/A
15.2.e	Control de potencia-frecuencia	≥C	5.4	P	P

"5.4. Capacidad de control de potencia-frecuencia

El objetivo es verificar que el MGE es capaz de ofrecer funciones que cumplan las especificaciones del GRT, con el objetivo de restablecer la frecuencia a su valor nominal o de mantener los flujos de intercambio de potencia entre las zonas de control en sus valores programados, según lo indicado en:

- Artículo 15.2.e del Reglamento.

En virtud del artículo 45 del Reglamento, la conformidad del MGE con este requisito se podrá realizar a través de prueba, tanto a nivel UGE como MGE, o de certificado de equipo. No obstante, la evaluación de este requisito la realizará el GRT conforme a los protocolos de pruebas establecidos en la regulación vigente en el momento de la puesta en servicio del MGE, que indicará el GRT al propietario del MGE."

The referenced article 15.2.e [3] states the following:

*"with regard to **frequency restoration control**, the power-generating module shall provide functionalities complying with specifications specified by the relevant TSO, aiming at restoring frequency to its nominal value or maintaining power exchange flows between control areas at their scheduled values;"*

7. Summary

The following table reflects the evaluation in terms of Grid Code compliance for a WF comprised of a certain type of WTGs. This summary table is based in **the AM0 of the SGRE WTGs**.

		Section	SG 5.X-170 (9)
			PPC
	Frequency Operation Range	5.1.1	✔ Compliance
	Voltage Operation Range	5.1.2	⏩ Wind Farm Study Needed
	Voltage/Frequency Operation Area	5.1.3	⏩ Wind Farm Study Needed
	Reactive Power Operation Range	5.1.4	⏩ Wind Farm Study Needed
Fault Ride Through	Current Support	5.2.1	✔ Compliance
	Active Power Recovery after Clearance	5.2.2	✔ Compliance
	Consecutive Voltage Dips	5.2.3	✔ Compliance
	Active Power/Frequency Regulation	5.3	? To be Clarified (1)(2)(3)
	Reactive Power/Voltage Regulation	0	✔ Compliance (4)
	Power Quality	5.5	⏩ Wind Farm Study Needed
	Communications	5.6	? To be Clarified (5)
	Protections	5.7	✔ Compliance
	Electrical Simulation Models	5.8	🛠 Development in Progress
	WF Simulation / Test / Certification	5.9	✔ Compliance
	Phase Jump	5.10.1	✔ Compliance
	Inertia Emulation	5.10.2	✕ Non-compliance (8)
	Power Oscillations Damping (POD)	5.10.3	🛠 Development in Progress
	System Strength	5.10.4	⏩ Wind Farm Study Needed
	Reconnection Blockage / Synchronization to the Grid	5.10.5	✔ Compliance

Table 23 Summary.

Legend	Description
✔ Compliance	Compliance is expected
Development in Progress	A SCADA or WTG development is planned or underway in order to assure compliance
⚠ Request development upon need	A specific development is required and shall be requested when a project needs to comply with this requirement.
To be Clarified	The requirement is not clear, or information is missing. Therefore, it shall be clarified with the Operator.
✕ Non-compliance	The requirement cannot be fulfilled.
Wind Farm Study Needed	Wind Farm Study Needed

Table 24 Legend.

Remarks:

(1) The requirements related with the MRPF and frequency restoration highlighted in sections 6.1 and 0 **must be clarified**.
(2) It must be agreed with SO, the mode of operation of the reactive power/voltage control and its final parameter settings in the corresponding connection agreement.
(3) The final WF signals list should be established in the connection agreement.
(4) **According to Certification Report Fault Ride Through** [13]**,** [14]**,** [15]**,** [16]**, we could comply**
(5) **The Grid Code has only been analyzed against the SG5.X-170. Reference document** [10] **is only valid for 170 rotor diameter variants. The grid capability document for SG5.X-155 variant (155 rotor diameter) is under development.**

8. References

[1] BOE-A-2020-7439, “Real Decreto 647/2020, de 7 de julio, por el que se regulan aspectos necesarios para la implementación de los códigos de red de conexión de determinadas instalaciones eléctricas”, 08/July/2020.

[2] BOE-A-2020-8965, “Orden TED/749/2020, de 16 de julio, por la que se establecen los requisitos técnicos para la conexión a la red necesarios para la implementación de los códigos de red de conexión, 01/Agust/2020”.

[3] Reglamento (UE) 2016/631 de la comision de 14 de abril de 2016 que establece un codigo de red sobre requisitos de conexion de generadores a la red, 2016.

[4] Norma técnica de supervisión de la conformidad de los módulos de generación de electricidad según el reglamento UE 2016/631, Revisión 2.1, 09/July/2021.

[5] P.O. 9 Información intercambiada por el operador del Sistema, 20/December/2019.

[6] Condiciones de Validacion y Aceptacion de los Modelos, Revision June/2020.

[7] “Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red”, Revision June/2020..

[8] “Requisitos de los modelos de instalaciones FACTS”, Revision June/2020.

[9] BOE-A-2021-904, “Circular 1/2021, metodología y condiciones del acceso y de la conexión a las redes de transporte y distribución de las instalaciones de producción de energía eléctrica.

[10] SG 5.X-170: D3120497, "SGRE ON SG6.2, SG6.6-170 Capabilities"..

[11] SG 5.X PLATFORM: D2904942, "Reactive Power Capaility - 50 & 60Hz.

[12] SG5.X PLATFORM: D2097474, "SGRE ON SG5X Inertial Response".

[13] CR-GCC-NTS631-08094-A066-0 - Fault-ride-through__final.

[14] CR-GCC-NTS631-07893-A066-0 - Fault-ride-through.

[15] CR-GCC-NTS631-07610-A066-0 - Fault-ride-through_final.

[16] CR-GCC-NTS631-08008-A066-0 - Fault-ride-through_final.

i	The latest released version of these documents must always be reviewed.