



HL-LHC HEL Powering System WP5.3.2.2 (provisional, from today's APT)

Michele Martino
on behalf of SY-EPC



HEL kick-off meeting – Zoom – April 13th 2021

HEL Powering System - Strategy

- SY-EPC in charge of two different sub-systems:
 - HV circuits (e-beam) powering : DC part
 - Magnets circuits powering
- Strategy outlined in the DMR [LHC-THE-ED-003 v.1.2](#)
 - “[...] EPC will prepare an **updated proposal** for the powering of the HEL. This proposal will be inspired by the **general principle of recovering from LHC as much equipment as possible** in order to **minimize cost** impact on HL-LHC budget.”
 - “[...] for the HV (DC [...]) part of the HEL circuits only a “**CERN internal solution**” could be considered ([...] **deliverables** to be **provided by [...]**EPC for the DC part [...]).”



HEL Powering System – HV Circuits

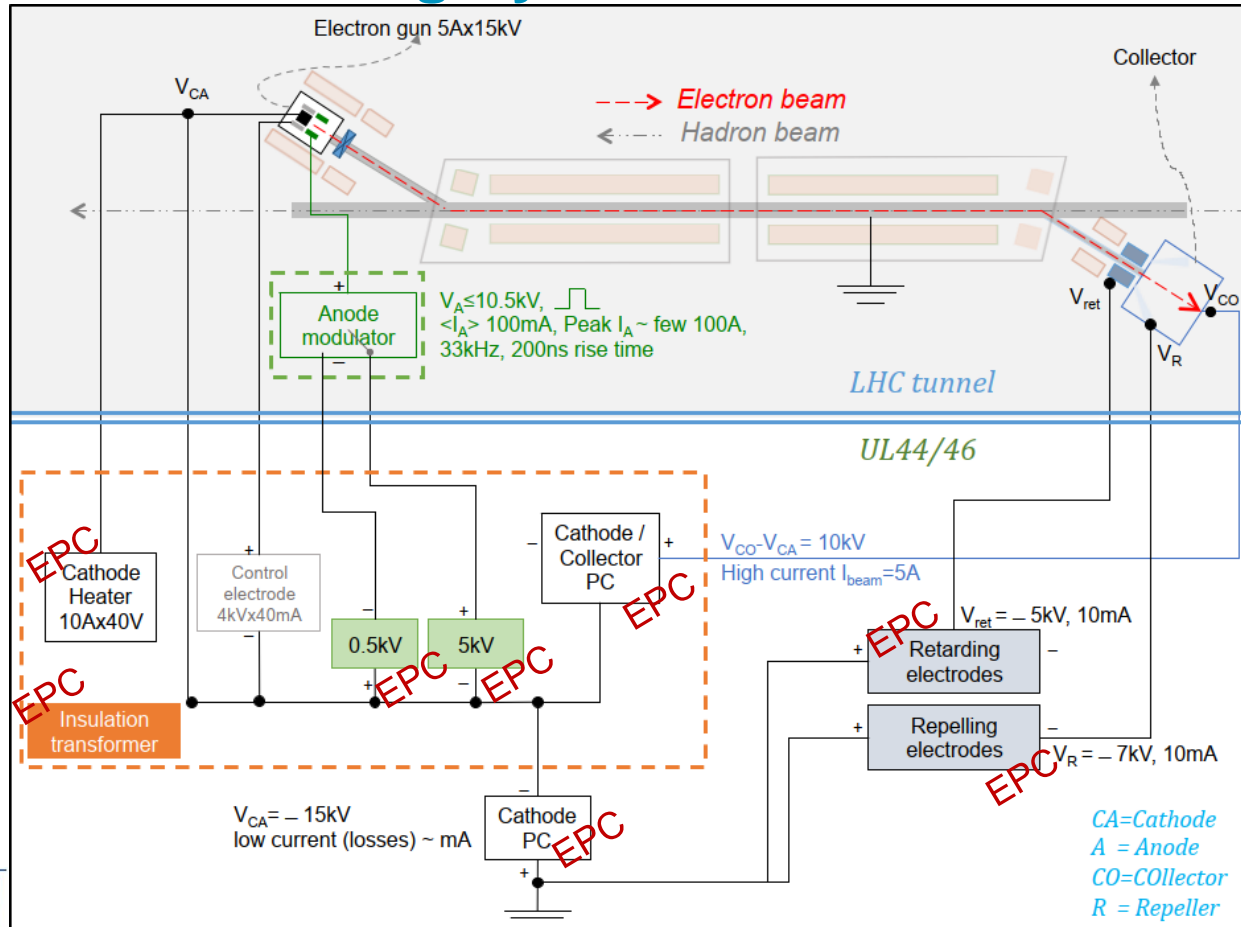


HEL Powering System – HV circuits

- Based on [LHC-THE-ES-0002 v.0.1 EDMS 2265586](#)
 - Last update May 25th 2020 – still a **DRAFT**, pending finalization
 - **DRAFT** is quite different from [EDMS 2186609 v.1.0](#)

HEL Powering System – HV circuits

EDMS 2265586 v.0.1
May 25th 2020



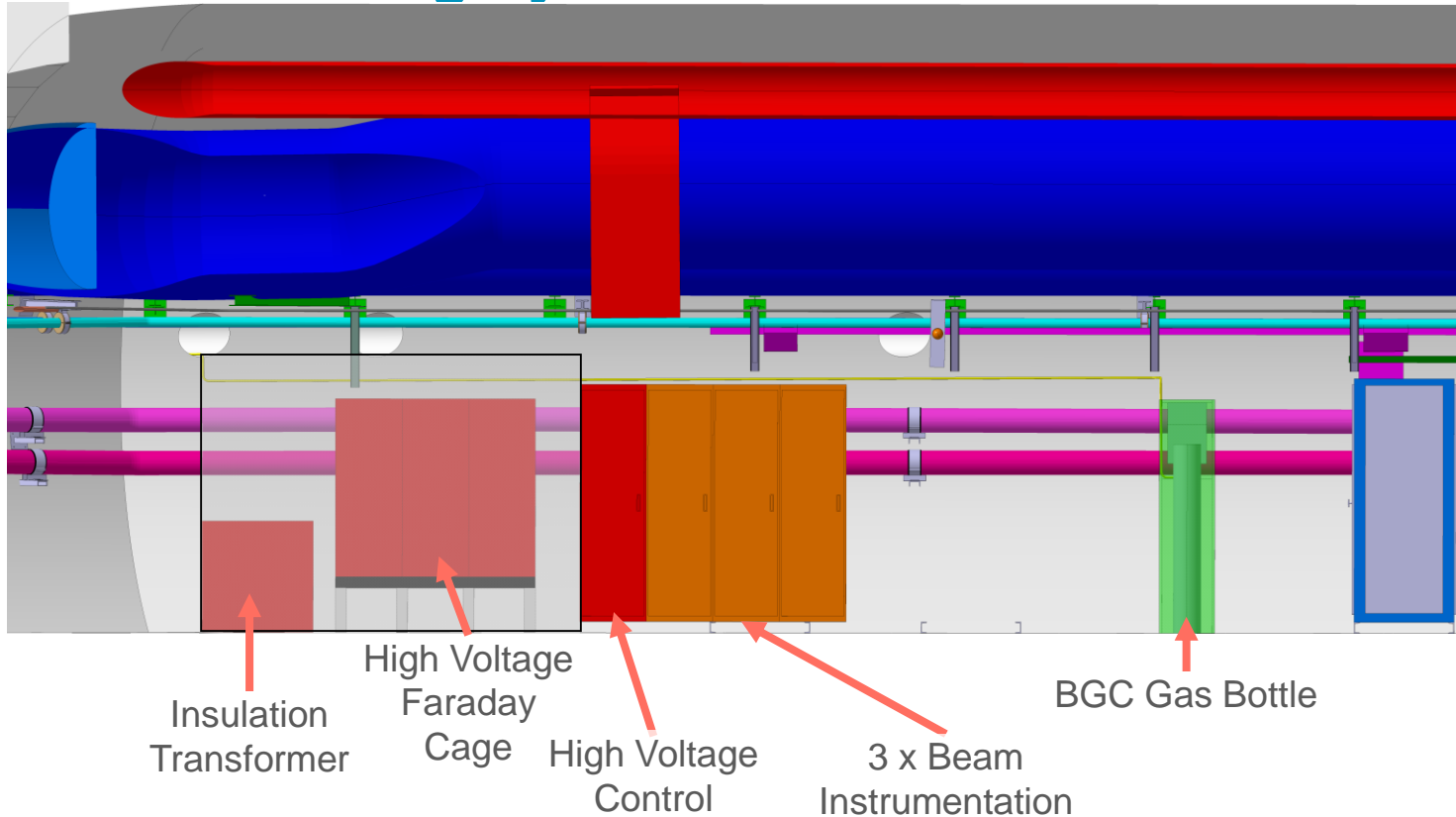
HEL Powering System – HV circuits

HEL HV powering: 1 lens

Equipment	Quantity	WP5 Specified Ratings	Type	Specified “Precision”	SY-EPC Proposed Ratings	Comments
Cathode Filament	1	10 A × 40 V	DC	0.1 A	12 A × 70 V	
Anode Modulation +	1	10 mA × -0.5 kV	DC	0.1 kV	20 mA × -6.5 kV	
Anode Modulation -	1	10 mA × 5kV	DC	0.1 kV	20 mA × 6.5 kV	
Cathode Collector	1	7 A × 10 kV	DC	0.1 kV	8 A × 10 kV	7 A is to keep margins
HV “Safety Crate”	1					Including safe access system
Cathode	1	10 mA × 15 kV	DC	0.1 kV	15 mA × 20 kV	
Retarding	1	10 mA × -5 kV	DC	0.1 kV	20 mA × -6.5 kV	
Repelling	1	10 mA × -7 kV	DC	0.1 kV	20 mA × -12.5 kV	
Insulation Transformer	1		AC		400 V _{AC} × 70 kVA	
Transformer MCB	1		AC			
Cables	7+1		DC			

Note: standard, non rad-tol, electronics (baseline being validated by “WP10”)

HEL Powering System – HV circuits @ UL44/UL46



Note: Beam Instrumentation inside the Faraday Cage, volume and access rights to be clarified



HEL Powering System – Magnets Circuits



HEL Powering System – Magnets circuits

- Based on MCF Table v 1.0 including **latest updates**
 - Number of circuits increased from [EDMS 2186609/v.1.0](#)

Circuits for HEL	Magnet Type	Circuit Name	I_{nominal} [A]	L per circuit at nominal current [mH]	Magnetic Energy [kJ]	R per circuit [m Ω] (*)	PC rated current [A]	PC Precision (*)	PC rated voltage [V]	Crowbar Resistance [m Ω]
Gun Solenoid 2	MLEG	RLEG	257	833.9	27.54	9	±600	Class 4	± 10	50
Gun Solenoid 1 and After Valve Solenoid	MLEA	RLEA	320	519.6	26.604	9	±600	Class 4	± 10	50
Bending Solenoid	MLEB	RLEB[1,2]	335	799.1	44.84	9	±600	Class 4	± 10	50
Main Solenoid	MLEM	RLEM[1,2]	330	8365.7	455.513	9	±600	Class 3	± 10	50
Dipole Compensator	MCBEC	RCBEC	220	116	2.808	9	±600	Class 4	± 10	50
Collector Solenoid	MLEC	RLEC	100	382	1.91	54	±120	Class 4	± 10	80
Electron Gun Corrector – Vert. & Hor.	MCBEG	RCBEG[V,H]	110	27	0.164	54	±120	Class 4	± 10	80
Main Solenoid Orbit Correctors	MCBEM	RCBEM[V,H][1,2,3,4,5,6]	120	5	0.028	54	±120	Class 4	± 10	80

(*): provisional values **pending final validation** [Precision Classes defined in [CERN-ACC-2019-0030](#)]

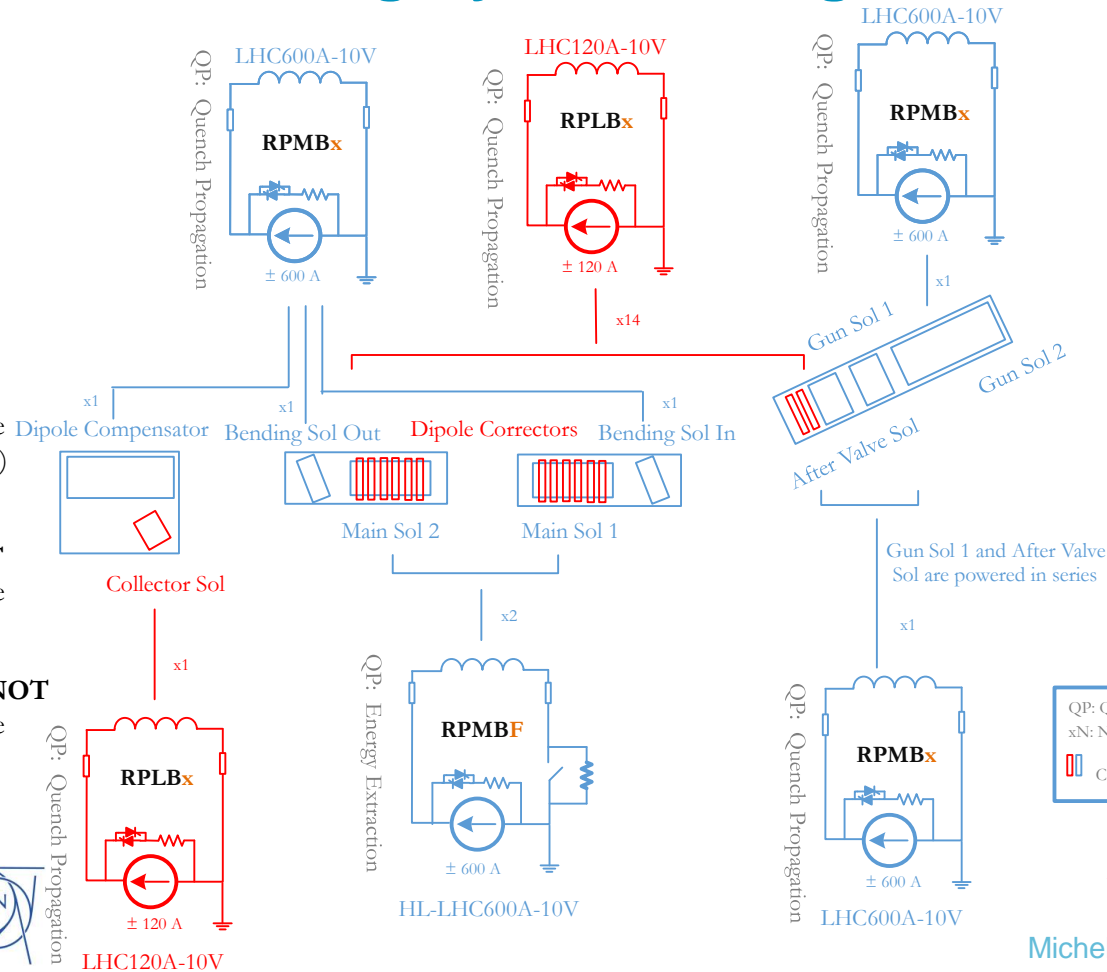
- Basic assumption: **individually controlled circuits**
 - circuits are magnetically coupled but only 1 circuit ramping (down) with energy
 - individual control should work, but not assessed yet → **if not R&D might be required \$\$\$**

HEL Powering System – Magnets circuits

LHC120A-10V PCs will guarantee the protection of the 120A current leads (as in LHC) (if new CL LHC-compatible)

LHC600A-10V PCs will **NOT** guarantee the protection of the current leads (as in LHC)

HL-LHC600A-10V PCs will **NOT** guarantee the protection of the current leads (as in LHC)



QP: Quench Protection
 xN: Number of Circuits per IP Side
 Current Leads Connection

Legend

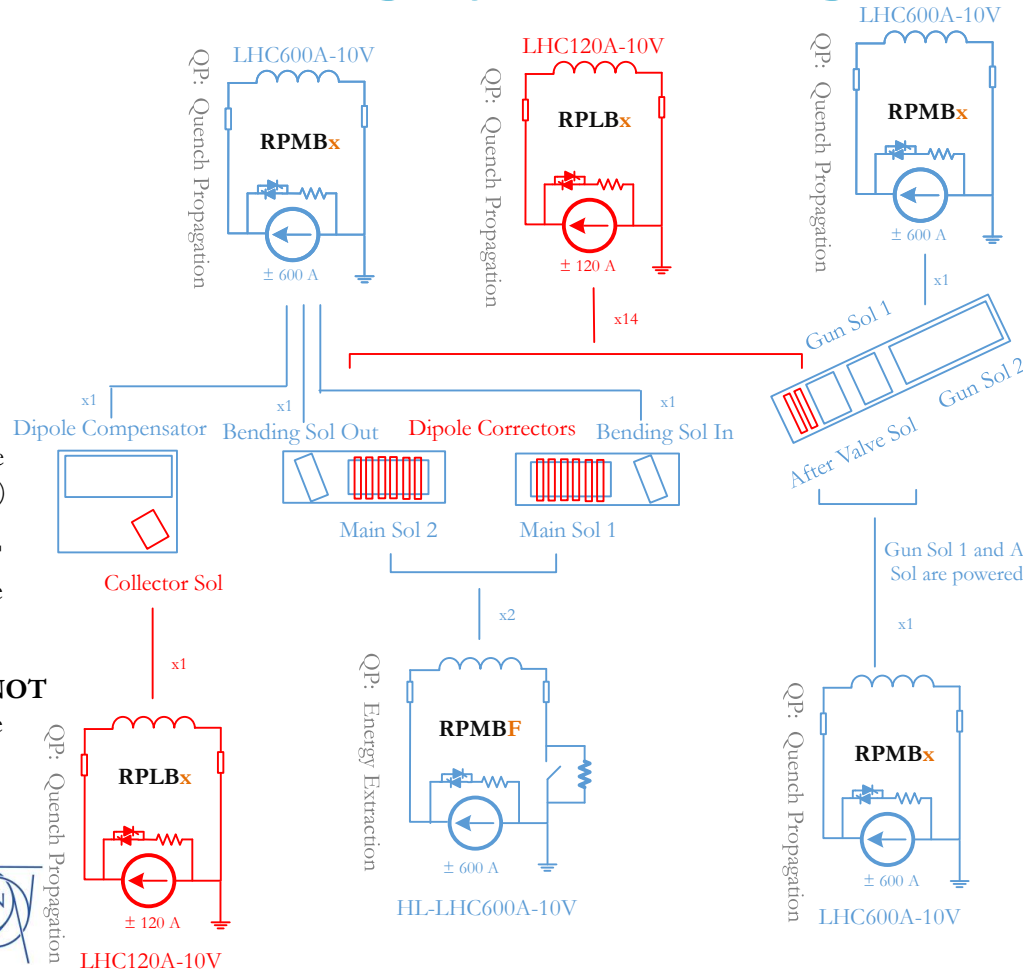
Hollow Electron Lens
 Circuits Layout V1.0

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HEL magnets powering: 1 lens		
Power Converter	LHC Recovery	#
RPMBF	No	2
RPMBx	Yes	5
RPLBx	Yes	15
Total		22

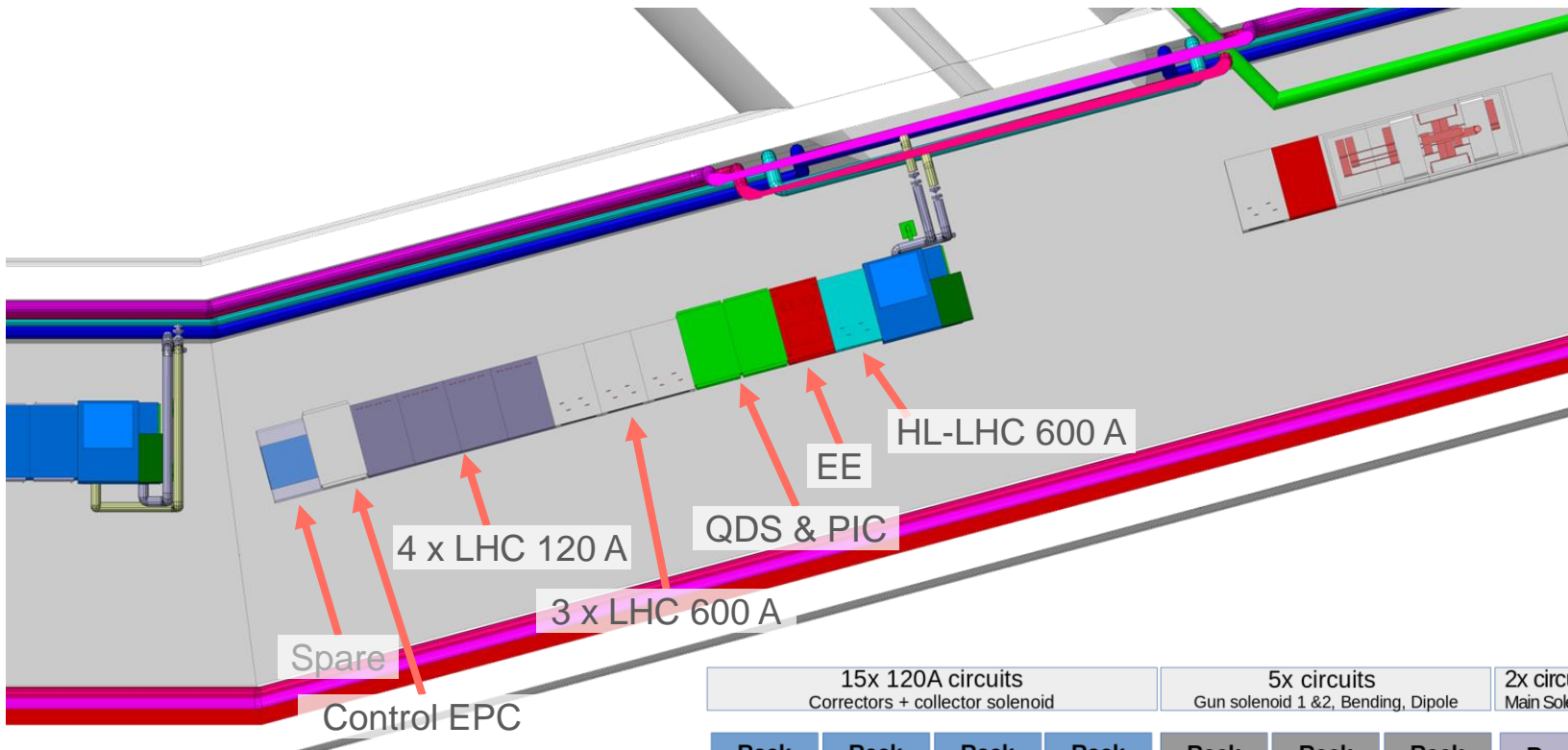
Note: standard electronics

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Legend

Hollow Electron Lens
 Circuits Layout V1.0

HEL Powering System – Magnets circuits @ UA43



15x 120A circuits Correctors + collector solenoid	5x circuits Gun solenoid 1 & 2, Bending, Dipole	2x circuits Main Solenoid
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Rack	Rack	Rack	Rack	Rack	Rack	Rack	Rack
LHC120A	LHC120A	LHC120A	LHC120A	LHC600A	LHC600A	LHC600A	HL-LHC600A
Air-Cooled	Air-Cooled	Air-Cooled	Air-Cooled	water-Cooled	water-Cooled	water-Cooled	water-Cooled
4x cvs slots	4x cvs slots	4x cvs slots	4x cvs slots	2x cvs slots	2x cvs slots	2x cvs slots	2x cvs slots
3x cvs used	4x cvs used	4x cvs used	4x cvs used	1x cvs used	2x cvs used	2x cvs used	2x cvs used



Thank you for your kind attention



Thanks to Valerie, Yves, Julien, Davide, Christophe, Joao

HEL Powering System – Excluded from Scope

WP5.3.2.2 (2 lenses)	
Services/Infrastructure	Interface Group <i>Tentative</i>
Air and Water Cooling <i>Including equipment for final interconnection to SY-EPC racks</i>	EN-CV
DC Cables for magnets circuits AC Distribution (cables, switchboard,...)	EN-EL
Interlocks (incl. cabling, etc...)	TE-MPE EN-EL
Transport	EN-HE