ATTACHMENT A5.3.2
SHUNT REACTOR SPECIFICATION AND DATA SHEET

1 EQUIPMENT SPECIFICATION CK0142/0011/EQUIP - SHUNT REACTORS

2 DATA SHEET - SHUNT REACTORS

SHUNT REACTORS
EQUIPMENT REQUIREMENTS SPECIFICATION – 0011/EQUIP
RIVERA FREQUENCY CONVERTOR STATION

1. GENERAL

The shunt reactor units are arranged in star connection with the neutral not connected to ground. The reactors units will be arranged in 3-phase banks, located outdoors in fenced compounds and will be switched into and out of service regularly to assist in control of the ac voltage on two 15 kV busbars associated with the HVDC convertor. One busbar operates at 50 Hz, the other busbar operates at 60 Hz.

Dry-type coils are required and shall be designed so as to avoid local overheating in transient conditions and to eliminate visible corona.

All reactors shall be designed, manufactured and tested to comply with relevant IEC standards and recommendations.

The equipment shall be supplied in accordance with the requirements given in UTE SU-10, UTE SU-18, and UTE SU-21.

The reactor units shall be mounted at ground level on suitable insulators and supports.

2. QUANTITY

The numbers of single phase reactor coils are as follows:

Unit type (Bank rating)	Number required	Reactor Unit Reference
5.17 MVAr (50 Hz)	6	=U =R1 +W2 -L10101 =U =R1 +W2 -L10201 =U =R1 +W2 -L10301
10.33 MVAr (50 Hz)	6	=U =R2 +W2 -L10101 =U =R2 +W2 -L10201 =U =R2 +W2 -L10301
10.33 MVAr (60 Hz)	3	=B =R1 +W2 -L10101 =B =R1 +W2 -L10201 =B =R1 +W2 -L10301

3. ENVIRONMENT

The equipment shall meet the specified performance when in service in the intended location and when subjected to the following environmental conditions.

3.1.	Location:	Rivera City, Uruguay
3.2	Height above mean sea level:	<1000 m
3.3.	Location on site:	Outdoor
3.4.	Outdoor Environment.	
3.4.1	Climate classification:	Sub-Tropical
3.4.2	Design air temperature (dry bulb)	
	• Maximum	45 deg. C
	• Minimum	-5 deg. C
3.4.3	Design air temperature (Wet bulb)	
	• Maximum	26 deg. C
	Design maximum relative humidity	91 %
	Design wind velocity	66 km/h averaged over 10 minutes Standard deviation 13.2 km/h
	Annual average rainfall	1065 mm
	Maximum rainfall intensity	24-hour maximum 117 mm
	Snow/ice loading	Unlikely
	Solar radiation (10 minutes)	1160 W/m^2
	Pollution	low
	Earthquake design criteria	None
	Isokeraunic level	40

4. TECHNICAL DATA

4.1 General Data

Reactor Unit	5.17 MVAr (50 Hz)	10.33 MVAr (50 Hz)	10.33 MVAr (60 Hz)
Nominal voltage	15 kV rms	15 kV rms	15 kV rms
Highest continuous voltage	17.5kVrms	17.5kVrms	17.5kVrms)
TOV capability	To be stated by supplier	To be stated by supplier	To be stated by supplier
Frequency	50 Hz	50 Hz	60 Hz
Frequency variation (Continuous)	± 0.5 Hz	± 0.5 Hz	± 0.5 Hz
Frequency variation (10 seconds)	± 2.0 Hz	± 2.0 Hz	± 2.0 Hz
Inductance at rated voltage	138.5 mH	69.33 mH	57.78 mH
Tolerance	± 2%	± 2%	± 2%
Capacitance at rated voltage	To be stated by supplier	To be stated by supplier	To be stated by supplier
BIL to ground & terminal to terminal	95 kV peak	95 kV peak	95 kV peak
Power frequency withstand to ground & terminal to terminal	38.5 kV rms	38.5 kV rms	38.5 kV rms
Surge arrester LIPL across the reactor	28 kV peak	28 kV peak	28 kV peak
Surge arrester SIPL across the reactor	26 kV peak	26 kV peak	26 kV peak
Creepage distance	>20 mm/kV*	>20 mm/kV*	>20 mm/kV*
Harmonic voltage on 15 kV busbar	1% 3rd 0.2% 5th	1% 3rd 0.2% 5th	1% 3rd 0.2% 5th

Note: * creepage is based on 20 mm/kV (rms) of maximum rated phase to phase voltage.

4.2 Duty

The shunt reactors will be switched frequently. The switching will be carried out by vacuum switchgear that will result in rapid current chopping. A zinc oxide surge arrester will be connected directly across the reactor terminals, to limit the peak voltage that may be induced by the reactor during this event. The reactor shall not suffer any failure due to this continuous duty.

SHUNT REACTORS

			TYPE A	TYPE B	TYPE C
1.0	**General Data**				
1.1	Manufacturer		ER	ER	ER
1.2	Standard		IEC 289	IEC 289	IEC 289
1.3	Type of insulation		air	air	air
1.4	Type of mounting		side-by-side	side-by-side	side-by-side
1.5	Number of phases per item of equipment		1	1	1
1.6	Location of installation		outdoors	outdoors	outdoors
2.0	**Rated Values and Characteristics**				
2.1	Rated current	A	200	398	398
2.2	Total harmonic current, including fundamental	A	N/A	N/A	N/A
2.3	Rated voltage	kV	15	15	15
2.4	Total harmonic voltage, including fundamental	kV	N/A	N/A	N/A
2.5	Maximum service voltage	kV	17.5	17.5	17.5
2.6	Rated frequency	Hz	50	50	60
2.7	Power rating	MVA	5.17	10.33	10.33
2.8	Resistance at service temperature of 75 °C and at rated frequency	Ω	0.413	0.1515	0.1484
2.9	Resistance measured with direct current at a) 20 °C b) 75 °C	 Ω Ω	 0.25 0.31	 0.078 0.095	 0.068 0.083
2.10	Resistance at tuning frequency	Ω	N/A	N/A	N/A
2.11	Losses (with rated current) a) at 20 °C: I^2R (DC) / Total (AC) b) at 75 °C: I^2R (DC) / Total (AC)	 kW kW	 10.0 / 11.5 12.2 / 16.5	 12.3 / 14.0 15.1 / 24.0	 10.7 / 12.5 13.1 / 23.5
2.12	Inductance for rated current at rated frequency	mH	138.5	69.33	57.78
2.13	Inductance at tuning frequency	mH	N/A	N/A	N/A
2.14	Rise above ambient temperature of 45 °C for rated operation (with rated current) a) Winding (through variation of resistance) b) Oil, where applicable (upper layer)	 °C °C	 50 N/A	 55 N/A	 55 N/A
2.15	Tolerance on values of inductance at minimum impedance frequency of filter	± %	2	2	2
2.16	Type of cooling		air natural	air natural	air natural
2.17	Maximum noise level a) Value (2 meters from winding surface) b) Measured in accordance with standards	dB	< 70 IEC 551	< 80 IEC 551	< 80 IEC 551
2.18	Type and commercial brand of oil		N/A	N/A	N/A
2.19	Maximum permissible thermal current a) 1 second b) 3 seconds	 kA kA	 N/A N/A	 N/A N/A	 N/A N/A
2.20	Maximum permissible dynamic peak current	kAp	N/A	N/A	N/A
2.21	Permissible steady-state overcurrent - Time - Value	 hr A	 1.0 refer to curve	 1.0 refer to curve	 1.0 refer to curve
2.22	Maximum radio-interference voltage - RIV (with maximum system voltage) - Measured in accordance with standard	µV	< 125 NEMA 107	< 125 NEMA 107	< 125 NEMA 107
3.0	**Insulation Levels**				
3.1	Type of insulation		air	air	air
3.2	Full wave, 1.2/50 µs a) Phase terminal b) Neutral	 kVp kVp	 95 95	 95 95	 95 95
3.3	Phase-to-earth switching overvoltage a) Phase terminal b) Neutral	 kV kV	 N/A N/A	 N/A N/A	 N/A N/A
3.4	Switching overvoltage between phases	kV	N/A	N/A	N/A

3.5	Power-frequency withstand voltage (phase-to-earth), 1 minute	kV	38.5	38.5	38.5
3.6	BIL of post insulators	kVp	110	110	110
4.0	**Characteristics of bushings**				
4.1	Manufacturer		N/A	N/A	N/A
4.2	Type of construction of insulator		N/A	N/A	N/A
4.3	Rated currents of bushings	A	N/A	N/A	N/A
4.4	Thermal and dynamic current		N/A	N/A	N/A
4.4.1	Short-duration thermal current (1 sec)	A	N/A	N/A	N/A
4.4.2	Rated dynamic current, peak value	A	N/A	N/A	N/A
4.5	Leakage distance of bushing	m	N/A	N/A	N/A
4.6	Insulation level of bushing		N/A	N/A	N/A
4.6.1	Full wave, 1.2/50 μs (BIL) (peak value)	kV	N/A	N/A	N/A
4.6.2	Switching overvoltage (peak value)	kV	N/A	N/A	N/A
5.0	**Design data**				
5.1	Insulating material of conductors		polyester film	polyester film	polyester film
5.2	Material of winding conductors		aluminum	aluminum	aluminum
5.3	Maximum current density in winding	A/mm^2	1.2	1.06	1.03
5.4	Cross-section of winding conductor	mm^2	194	938	450
5.5	Number of taps for filter tuning		N/A	N/A	N/A
5.6	Insulation class according to IEC standards		B	B	B
5.7	Number of turns in winding (average)		334	247	239
5.8	Characteristics of magnetic core		N/A	N/A	N/A
5.9	Tank and expansion tank		N/A	N/A	N/A
5.10	Maximum loads applicable to terminals a) Along x-axis (vertical) F(-x) F(+x) b) Along y-axis (longitudinal) F(-y) F(+y) c) Along z-axis (transverse) F(-z) F(+z) d) Moment according to x-axis, M(x)	 daN daN daN daN daN daN daN·m	 100 100 200 200 100 100	 100 100 200 200 100 100	 100 100 200 200 100 100
5.11	Connection terminals a) Material b) Shape c) Dimensions d) Rated current	 inches A	 Al alloy flat bar 4 x 4 x 0.5	 Al alloy flat bar 4 x 4 x 0.5	 Al alloy flat bar 4 x 4 x 0.5
5.12	Earthing terminals a) Material b) Type c) Cross-section of copper earth	 mm^2	 N/A N/A N/A	 N/A N/A N/A	 N/A N/A N/A
5.13	Brand and type of post insulators		Santana TR205	Santana TR205	Santana TR205
6.0	**Dimensions, volumes and weights**				
6.1	Weight of complete reactor	kg	1756	2517	2379
7.0	**Test program** 1) Measurement of DC Resistance 2) Measurement of Reactance 3) Measurement of Loss 4) Separate-source voltage withstand test on the insulators 5) Induced overvoltage withstand test replaced by a lightning impulse test		 as indicated routine tests per IEC 289	 as indicated routine tests per IEC 289	 as indicated routine tests per IEC 289