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巴基斯坦默蒂亚里-拉合尔±660高压直流输电工程系统调试方案

（5）单极大功率系统调试方案

Matiari-Lahore ±660kV HVDC Transmission Project Commissioning Tests

(5) Monopole High Power System Tests Program

China Electric Power Research Institute

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内容摘要

巴基斯坦默蒂亚里-拉合尔高压直流输电工程单极大功率系统调试方案内容包括:极起/停,功率升降,手动分接头控制,大地/金属转换,热运行试验,特殊测量试验。其中详细列出了每个试验项目内容、步骤及验收标准等。

关键词:巴基斯坦默拉直流;单极大功率系统调试方案;系统调试

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**1 Preconditions**

**1试验条件**

IMPORTANT: The pole power during the tests shall be up to 2200 MW, corresponding to 3333 A. The AC voltage at all the two converter stations including Matiari and LAHORE shall be 505-525kV before and during all tests.The frequency at all the three converter stations shall be 49.5-50.5Hz.

重要提示:试验期间的极功率应高达2200MW，相当于3333A。在所有试验之前和期间，默蒂亚里和拉合尔两个换流站的交流电压应为505-525kV。两个换流站的频率应为49.5-50.5赫兹。

Before starting of monopole high power tests, the following activities must have been completed:

在开始单极大功率测试之前，必须完成以下测试:

- The low power monopolar tests

-单极小功率测试

- Verify that the cooling equipment for converter transformers, smoothing reactor and thyristor valves are operating properly, with the correct switching of fans and pumps.Moreover, it must be checked that the redundant pumps, fans, and heat exchangers are available.

-验证换流变压器、平波电抗器和阀冷设备运行正常，风扇和泵切换正确。此外，必须检查冗余泵、风扇和冷却器是否可用。

- The thyristor valve cooling pumps are running for more than 24 hours and all air bleeding valves are checked.

-换流阀冷却泵运行超过24小时，并检查所有排气阀。

Furthermore, the following pre-conditions apply for all tests defined in this procedure.If any particular pre-condition is necessary for a specific test, it will be added in the test description.

此外，以下试验条件适用于本程序中定义的所有测试。如果特定测试需要任何特定的试验条件，则该条件将被添加到测试描述中。

- The test leader from CEPRI and Owner must be appointed.

-必须任命CEPRI和业主的测试负责人。

- All equipment tests and subsystem tests of equipment involved in this test must be completed.

-必须完成本测试中涉及的所有设备测试和设备子系统测试。

- Low voltage tests completed

-低压测试完成

- AC-switchyard and associated protections and sequences, including breaker failure protection, tested

-交流开关和相关保护，包括断路器失灵保护调试完成

- Final trip test done on each area prior to deblocking.

-解锁之前，对每个区域进行最后的跳闸测试。

- Verify list of remaining activities and make sure that the test can proceed.

-验证剩余试验项目，并确保测试可以继续进行。

- Verify list of temporary connections and make sure that the test can proceed.

-验证临时连接列表，并确保测试可以继续进行。

- Verify Sequence of Events Recorder (SER) and make sure no relevant alarms are present and that all systems are operational.

-验证事件记录器(SER)的顺序，并确保不存在相关警报，且所有系统均可运行。

- Prior to each test, select the relevant TFR points that will be recorded, stored, and used as test records.

- 每个测试之前，选择将被记录、存储并用作测试记录的相关TFR点。

- The switching sequence prepared by Owner is ready and the station (or all equipment involved in the test) is handed over for operation.

-业主准备的切换顺序已准备就绪，车站(或测试中涉及的所有设备)已移交运行。

**2 Pole 1 High Power Test(Normal Power Direction)**

**2极1大功率测试(正常功率方向)**

**2.1 Test Objective**

**2.1测试目标**

The test objective is to check DC equipment performance during high power test.

测试目的是在大功率测试期间检查DC设备的性能。

**2.2 Preconditions**

**2.2试验条件**

(1)all low power tests have been finished.

(1)所有小功率测试已经完成。

(2)AC system precondition:

(2)交流系统试验条件:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

1)两个交流系统的500kV母线电压约为505~525kV。

2)Both sides of AC system are capable to supply the power for the test.

2)交流系统的两侧都能够为测试供电。

(3)DC system precondition:

(3)DC系统的试验条件:

默蒂亚里:

[X]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[ ] Q控制 [X] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

拉合尔:

[ ]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[X] Q控制 [ ] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

**2.3 Test Content and Procedure**

**2.3测试内容和程序**

**2.3.1 Pole Start**

**2.3.1极启动**

(1)Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from converter transformers.

(1)热运行试验开始前，应从换流变压器中提取DGA(溶解气体分析)样品。

(2)Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a 'Ready for Operation' condition.

(2)按照业主的操作说明操作断路器和开关，使变频器进入“准备运行”状态。

(3)Verify both stations in 'Ready for Operation' condition.

(3)验证两个站都处于“准备运行”状态。

(4)According the actual situation and test requirement, verify the DC configuration is GROUND RETURN(GR) or METALLIC RETURN(MR).

(4)根据实际情况和试验要求，验证DC配置为接地回路或金属回路。

(5)Switch RPC to Q control in both stations.

(5)将两个站中的RPC切换到Q控制。

(6)Start the pole at minimum power in Normal Power Direction, Metallic Return Operation,200MW (303A), ramp rate 100MW/min.

(6)在(6)正常功率方向、金属回线方式，200MW (303A)，斜坡率100MW/min，以最小功率启动该极。

(7)Record and save all data.

(7)记录并保存所有数据。

**2.3.2 Power Ramp**

**2.3.2电压升降**

(1)Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW with an interval of 2 min.The interval is to make sure the system is stable.

(1)以50MW/分钟的速度，以200MW的步长将功率提升至2000MW，间隔2分钟。间隔是为了保证系统稳定。

(2)When Ramp power from 400MW to 600MW at 999MW/min ramp speed.

(2)当功率从400MW到600MW，速度为999MW/分钟时。

(3)Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(3)验证斜坡完成后功率达到参考值，斜坡过程平稳且无干扰。

(4)Verify:

(4)验证:

1)The reference is fulfilled after ramping in both stations at each power level.

1)在每个功率水平下，在两个站中斜坡上升之后，参考值被满足。

2)Stable operation at each power level.

2)各功率级稳定运行。

3)The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

3)在斜坡过程中，两个站中的活性粉末混凝土按照技术规范连接适当数量的过滤器和分流组。

(5)Perform Heat Run Test and Special Measurements as described in section 3.2.1-3.2.7.

(5)按照第 3.2.1-3.2.7节所述进行热运行试验和特殊测量。

(6)After the Heat Run Test and Special Measurements completed, Perform as Manual Tap Changer Step and Ground/Metallic Return Transfer described in section 3.2.1-3.2.7 at the power level 2000MW.

(6)完成热运行测试和特殊测量后，按照第2节中所述手动抽头切换开关步骤和接地/金属回路转换执行，功率水平为2000MW。

(7)Ramp the power down to 200MW at 50MW/min rate in steps of 200MW with an interval of 2 min.The interval is to make sure the system is stable.

(7)以50MW/分钟的速度，以200MW的步长将功率降低到200MW，间隔2分钟。间隔是为了保证系统稳定。

(8)When Ramp power from 800MW to 600MW at 999MW/min ramp speed.

(8)当斜坡功率从800MW到600MW，斜坡速度为999MW/分钟时。

(9)Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(9)验证斜坡完成后功率达到参考值，斜坡过程平稳且无干扰。

(10)Initiate a manual switchover from PCPA to PCPB and from PCPB to PCPA while ramp is in progress.

(10)当ramp正在进行时，启动从PCPA到PCPB以及从PCPB到PCPA的手动切换。

(11)Verify:

(11)验证:

1)the ramping process is smooth and continuous without transient changes in the power transmission.

1)斜坡过程是平滑和连续的，在功率传输中没有瞬时变化。

2)the references are fulfilled after the ramping is completed.

2)斜坡上升完成后，参考值被满足。

(12)Stop the pole.

(12)该极停止。

(13)Record and save test data.

(13)记录并保存测试数据。

**2.3.3 Tap Changer Control, Manual Tap Changer Step**

**2.3.3分接开关控制，手动分接开关步骤**

Notes: This test would be accomplished in parallel with 2.3.2.

注意:该测试将与2.3.2并行完成。

Matiari:

默蒂亚里:

(1)Set tap changer control in MANUAL CONTROL mode and decrease one steps for decreasing (1)U(1)di0(1).

(1)将抽头切换开关控制设置为手动控制模式，并减少一个步长以减少(1)U(1)di0(1)。

(2)Verify increased firing angle and maintained transmitted current.

(2)验证增加的触发角和保持的传输电流。

(3)Set the tap changer control back to AUTO CONTROL mode.

(3)将抽头切换开关控制设置回自动控制 模式。

(4)Verify that:

(4)验证:

1)The tap changer would automatically return to original position if the AC voltage remained unchanged.

1)如果交流电压保持不变，分接开关将自动返回到原始位置。

2)Firing angle back within control limits.

2)触发角回到控制范围内。

3)Maintained transmitted current.

3)保持传输电流。

LAHORE:

拉合尔:

(5)Set tap changer control in MANUAL CONTROL mode and decrease one steps for decreasing Udi0.

(5)将抽头切换开关控制设置为手动控制模式，并减少一个步长以降低Udi0。

(6)Verify:

(6)验证:

1)Decreased DC voltage

1)DC电压降低

2)Maintained gamma (γ) in LAHORE.

2)在拉合尔维持伽马(γ)。

3)Decreased tap position in Matiari to maintain firing angle within control limits.

3)减少默蒂亚里的抽头位置，以将触发角度保持在控制范围内。

4)Maintained transmitted current.

4)保持传输电流。

(7)Set the tap changer control back to AUTO CONTROL mode.

(7)将抽头切换开关控制设置回自动控制模式。

(8)Verify that:

(8)验证:

1)The tap changer would automatically return to original position if the AC voltage is unchanged.

1)如果交流电压不变，分接开关将自动返回到原始位置。

2)Firing angle back within control limits.

2)触发角回到控制范围内。

3)DC voltage back to nominal value.

3)DC电压回到标称值。

4)The tap position in Matiari is increased to maintain firing angle within control limits.

4)增加Matiari中的抽头位置，以将触发角保持在控制范围内。

5)Maintained transmitted current.

5)保持传输电流。

(9)Record and save test data.

(9)记录并保存测试数据。

**2.3.4 Ground/Metallic Return Transfer**

**2.3.4接地/金属回路转移**

Notes: This test would be accomplished in parallel with 2.3.2.

注意:该测试将与2.3.2并行完成。

(1)Verify that both stations are in the 'Ready For Ground Return Operation' condition (in software as well as by visual inspection).

(1)验证两个站都处于“具备大地金属回线”状态(通过软件和目视检查)。

Matiari:

默蒂亚里:

(2)Order TRANSFER TO METALLIC RETURN

(2)命令转移至金属回线。

(3)Verify:

(3)验证:

1)Correct sequential operation of switches and breakers.

1)开关和断路器的正确顺序操作。

2)Correct operation of MRTBin Matiari (The operation of the breaker should be observed visually carefully in order to interrupt the sequence in case of maloperation).

2)MRTB的正确操作在默蒂亚里(断路器的操作应仔细观察，以便在误操作的情况下中断顺序)。

3)No disturbance in power transfer.

3)动力传递无扰动。

4)Check the correctness whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

4)检查马蒂里和拉合尔的所有相关开关和断路器是否按照技术规范正确操作。

(4)Order TRANSFER TO GROUND RETURN.

(4)命令转移到地面返回。

(5)Verify:

(5)验证:

1)Correct sequential operation of switches and breakers.

1)开关和断路器的正确顺序操作。

2)No disturbance in power transfer.

2)动力传递无扰动。

3)Correct operation of GRTS in Matiari (The operation of the switch should be observed visually carefully in order to interrupt the sequence in case of maloperation).

3)在Matiari中GRTS的正确操作(应仔细观察开关的操作，以便在误操作的情况下中断顺序)。

4)Check the correctness whether all related switches and breakers in Matiari and LAHORE are correctly operated in line with the technical specification.

4)检查马蒂里和拉合尔的所有相关开关和断路器是否按照技术规范正确操作。

(6)Record and save all data.

(6)记录并保存所有数据。

**3 Pole 1 Heat Run Test and Special Measurements**

**3极1热运行测试和特殊测量**

**3.1 Preconditions**

**3.1试验条件**

The test objective is to carry on heat run test and special measurement during high power test.

试验目的是在大功率试验时进行热运转试验和特殊测量。

**3.2 Preconditions**

**3.2试验条件**

(1)all low power tests have been finished.

(1)所有小功率测试已经完成。

(2)AC system precondition:

(2)交流系统试验条件:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

1)两个交流系统的500kV母线电压约为505~525kV。

2)Both sides of AC system are capable to supply the power for the test.

2)交流系统的两侧都能够为测试供电。

(3)DC system precondition:

(3)DC体系的前提条件:

默蒂亚里:

[X]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[ ] Q控制 [X] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

拉合尔:

[ ]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[X] Q控制 [ ] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

**3.3 Test Content and Procedure**

**3.3测试内容和程序**

**3.3.1 Pole 1 Run at 1.00 p.u. in Monopole without Redundant Cooling**

**3.3.1极1以1.00功率单位的运行，无冗余冷却**

Notes: The procedure (1) - (5) would be accomplished in parallel with 2.2.2-2.2.4.

注:程序(1) - (5)将与2.2.2-2.2.4并行完成。

(1)Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis)shall be taken from converter transformers.

(1)热运行试验开始前，应从换流变压器中提取DGA溶解气体分析的样品。

(2)Switch RPC to Q control in both stations.

(2)将两个站的RPC切换到Q控制。

(3)Start the pole at minimum power in Normal Direction, metallic return operation,200MW (303A), ramp rate 100MW/min.

(3)以最小功率启动该极，正常方向，金属回线方式， 200MW（303）A，斜坡率100MW/min。

(4)Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

(4)以50MW/分钟的速度，以200MW的步长将功率提升至2000MW，间隔2分钟，在每增加200MW之间保持稳定运行:

(5)Keep the pole in operation for 4 hours at 1.0 p.u. The following verifications should be carried during this period.

(5)保持该极在1.0 p.u .下运行4小时。在此期间应进行以下验证。

1)Verify that the reference is fulfilled after the ramping is completed.

1)验证斜坡完成后是否满足参考。

2)Verify that the measured currents and voltages at DC and AC side are correct.

2)验证DC和交流侧的测量电流和电压是否正确。

3)Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable 3)temperature is reached (temperatures should be stable within approximately 15 minutes).

3)连续读取并记录阀门冷却水入口和出口温度(本地和/或远程指示)，直到达到合理的稳定温度3)温度(温度应在大约15分钟内稳定)。

4)Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

4)每30分钟(本地和/或远程指示)读取并记录换流变压器和平波电抗器中线圈绕组和热点的温度，直到达到合理的稳定温度(温度应在大约3小时内稳定)。

5)Read and record AC-side individual harmonics, Dn, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF,5) in Matiari and LAHORE.

5)读取并记录默蒂亚里和拉合尔的交流侧单个谐波、Dn、总谐波失真、总谐波失真、电话谐波形状系数、总谐波频率。

6)Read and record DC-side harmonics and Ieq in Matiari andLAHORE.

6)读取并记录DC侧谐波和默蒂亚里和拉合尔的电流。

7)Perform special measurements as described in below section 3.3.3-3.3.7.

7)按照以下第3.3.3-3.3.7节所述进行特殊测量。

8)The Power Loss in Station should be measured by subtracting the DC power from the power flowing into the converter transformer.

8)站中的功率损耗应通过从流入换流变压器的功率中减去DC功率来测量。

(6)Record and save all data.

(6)记录并保存所有数据。

(7)Keep pole running at 1.0 p.u. and proceed to the next item.

(7)保持该极以1.0 p.u .运行，并继续下一项。

**3.3.2 Pole 1 Run at 1.1 p.u. in Monopole with Redundant Cooling**

**3.3.2带冗余冷却的单极子中1.1功率单位的1极运行**

(1)Verify the pole 1 running at 1.0p.u. in metallic transfer return.

(1)验证该极1在金属转移回路中以1.0p.u. 运行。

(2)Ramp the power up to 2200MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

(2)以50MW/分钟的速度，以200MW的步长将功率提升至2200MW，间隔2分钟，在每增加200MW之间保持稳定运行:

(3)Keep the pole 1 in operation for 40 minutes at 1.1 p.u. The following verifications should be carried during this period.

(3)保持该极1在1.1 p.u .下运行40分钟。在此期间应进行以下验证。

1)Verify that the reference is fulfilled after the ramping is completed.

1)验证斜坡完成后是否满足参考。

2)Verify that the measured currents and voltages at DC and AC side are correct.

2)验证DC和交流侧的测量电流和电压是否正确。

3)Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

3)连续读取并记录阀门冷却水入口和出口温度(本地和/或远程指示)，直到达到合理的稳定温度(温度应在大约15分钟内稳定)。

4)Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

4)每30分钟(本地和/或远程指示)读取并记录换流变压器和平波电抗器中线圈绕组和热点的温度，直到达到合理的稳定温度(温度应在大约3小时内稳定)。

5)Read 5)and record AC-side individual harmonics, Dn, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

5)读取5)并记录交流侧单个谐波、Dn、总谐波失真、总谐波失真、电话谐波形状系数、总谐波频率，单位为默蒂亚里和拉合尔。

6)Read and record DC-side harmonics and Ieq in Matiari and LAHORE.

6)读取并记录默蒂亚里和拉合尔的DC侧谐波和Ieq。

7)Perform special measurements as described in below section 3.3.3-3.3.7.

7)按照以下第3.3.3-3.3.7节所述进行特殊测量。

8)The Power Loss in Station8) should be measured by subtracting the DC power from the power flowing into the converter transformer.

8)站8)中的功率损耗应通过从流入换流变压器的功率中减去DC功率来测量。

(4)Ramp the power down to 2000MW (3030A), at 50MW/min

(4)以50MW/min的速度将功率降低至2000MW (3030A)

(5)Record and save all data.

(5)记录并保存所有数据。

**3.3.3 Radio Interference Measurements**

**3.3.3无线电干扰测量**

To check if the radio and television interference generated by the HVDC plant is within the specified limit at the specified locations.

检查高压直流输电设备产生的无线电和电视干扰是否在指定位置的指定范围内。

(1)Choose 1 or 2 test places inside the converter stations and about 450m away outside the converter station and carry out the measurement of the interference frequency spectrum.

(1)在换流站内和换流站外约450米处选择1或2个测试地点，进行干扰频率频谱的测量。

(2)To measure the frequency spectrum characteristics of radio interference under the outlet line of the 660 kV valve hall and at 20 m from the outlet line inside the converter station.

(2)测量660kV阀厅出线下和换流站内出线20 m处的无线电干扰频谱特性。

(3)Record and save all data.

(3)记录并保存所有数据。

**3.3.4 Audible Noise Check**

**3.3.4声音噪音检查**

To check if the audible noise level, generated by the HVDC plant, is within the specified limits at specified locations.

检查高压直流输电设备产生的可听噪声水平是否在指定位置的指定限值内。

(1)Measurement of Audible noise near the convertor transformer in the converter station.

(1)测量换流站换流变压器附近的可听噪声。

(2)Measurement of Audible noise along the boundary line outside the converter station.

(2)测量换流站外边界线上的可听噪声。

(3)Measurement of Audible noise in front of the houses near the converter station, if there are houses.

(3)测量换流站附近房屋前的可听噪声(如果有房屋)。

(4)Record and save all data.

(4)记录并保存所有数据。

**3.3.5 Station Service Power Losses**

**3.3.5电站服务功率损失**

The aim of this test is to determine the losses of the auxiliary supply under load and no-load conditions.According to the study report, only the critical and essential loads of the equipment supplied are included.

该测试的目的是确定负载和空载条件下辅助电源的损耗。根据研究报告，仅包括所提供设备的临界和基本负荷。

(1)In status Ready for Operation, the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour).The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed losses.

(1)在状态准备运行中，在一个预定的时间段内测量400伏功率水平上的负载(例如，一小时内测量5次)。对测量结果进行平均，得到与空载或固定损耗相当的损耗值。

(2)Verify that these measured loss values should be within limited value specified by technical specification.

(2)验证这些测量的损失值应在技术规范规定的限值内。

(3)When the pole 1 is in operation at 1.0 p.u. or 1.1 p.u., the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour).The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed (3)losses.

(3)当该极1在1.0 p.u .或1.1 p.u .下运行时，在一个预定的时间周期内测量400伏功率水平上的负载(例如在一小时内测量5次)。对测量结果进行平均，得到与空载或固定(3)损耗相等的值。

(4)Record and save all data.

(4)记录并保存所有数据。

**3.3.6 Temperature Measurement With IR-Camera Equipment**

**3.3.6用红外摄像设备进行温度测量**

(1)Verify by use of IR-camera that the temperature of busbars, clamps conductors, equipment, etc.are acceptable in DC-yard, AC-yard, and valve hall.

(1)使用红外摄像机验证母线、夹具导体、设备等的温度。在DC场、交流场和阀厅是可以接受的。

(2)Record and save all data.

(2)记录并保存所有数据。

**3.3.7 Ground Electrode Test Program**

**3.3.7接地电极测试程序**

This test is to be carried out together with Heat Run Test, and it shall be conducted in both electrode sites simultaneously.

该试验应与热运行试验一起进行，并应在两个电极位置同时进行。

(1)Measure the electrode resistance by measuring the neutral bus voltage and the electrode current.

(1)通过测量中性母线电压和电极电流来测量电极电阻。

(2)Measure step and touch potentials at the electrode sites.

(2)测量电极位置的阶跃和接触电位。

(3)Measure the various cable current of the electrode.

(3)测量电极的各种电缆电流。

(4)Measure the temperature rise in the electrode conductor and the soil in the electrode site.

(4)测量电极导体和电极位置土壤的温升。

(5)Record all measurements mentioned above.

(5)记录上述所有测量值。

(6)Verify:

(6)验证:

1)The current distribution within the various parts cables of the electrode shall be within the design limits.

1)电极各部分电缆内的电流分布应在设计范围内。

2)Step and touch potentials must be within safe limits

2)阶跃和接触电位必须在A全范围内

3)The electrode conductor temperature shall be within the design limits.

3)电极导体温度应在设计限值内。

(7)Record and save all data.

(7)记录并保存所有数据。

**4 Pole 2 High Power Test(Normal Power Direction)**

**4极2大功率测试(正常功率方向)**

**4.1 Test Objective**

**4.1测试目标**

The test objective is to check DC equipment performance during high power test.

测试目的是在大功率测试期间检查DC设备的性能。

**4.2 Preconditions**

**4.2试验条件**

(1)all low power tests have been finished.

(1)所有小功率测试已经完成。

(2)AC system precondition:

(2)交流系统试验条件:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

1)两个交流系统的500kV母线电压约为505~525kV。

2)Both sides of AC system are capable to supply the power for the test.

2)交流系统的两侧都能够为测试供电。

(3)DC system precondition:

(3)DC体系的前提条件:

默蒂亚里:

[X]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[ ] Q控制 [X] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

拉合尔:

[ ]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[X] Q控制 [ ] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

**4.3 Test Content and Procedure**

**4.3测试内容和程序**

**4.3.1 Pole Start**

**4.3.1极启动**

(1)Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from converter transformers.

(1)热运行试验开始前，应从换流变压器中提取DGA(溶解气体分析)样品。

(2)Perform breakers and switches in line with the Owner Operation Instructions to bring the converter into a 'Ready for Operation' condition.

(2)按照业主的操作说明操作断路器和开关，使变频器进入“准备运行”状态。

(3)Verify both stations in 'Ready for Operation' condition.

(3)验证两个站都处于“准备运行”状态。

(4)According the actual situation and test requirement, verify the DC configuration is GROUND RETURN(GR) or METALLIC RETURN(MR).

(4)根据实际情况和试验要求，验证DC配置为接地回路或金属回路。

(5)Switch RPC to Q control in both stations.

(5)将两个站中的RPC切换到Q控制。

(6)Start the pole at minimum power in Normal Power Direction, Metallic Return Operation,200MW (303A), ramp rate 100MW/min.

(6)在正常功率方向、金属回线方式，200MW (303A)，斜坡率100MW/min，以最小功率启动该极。

(7)Record and save all data.

(7)记录并保存所有数据。

**4.3.2 Power Ramp**

**4.3.2电源斜坡**

(1)Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW with an interval of 2 min.The interval is to make sure the system is stable.

(1)以50MW/分钟的速度，以200MW的步长将功率提升至2000MW，间隔2分钟。间隔是为了保证系统稳定。

(2)When Ramp power from 400MW to 600MW at 999MW/min ramp speed.

(2)当斜坡功率从400MW到600MW，斜坡速度为999MW/分钟时。

(3)Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(3)验证斜坡完成后功率达到参考值，斜坡过程平稳且无干扰。

(4)Verify:

(4)验证:

1)The reference is fulfilled after ramping in both stations at each power level.

1)在每个功率水平下，在两个站中斜坡上升之后，参考值被满足。

2)Stable operation at each power level.

2)各功率级稳定运行。

3)The RPC in both stations connects the appropriate number of filters and shunt banks in line with the technical specification during the ramping process.

3)在斜坡过程中，两个站中的活性粉末混凝土按照技术规范连接适当数量的过滤器和分流组。

(5)Perform Heat Run Test and Special Measurements as described in section 5.2.1-5.2.6.

(5)按照第 5.2.1-5.2.6节所述进行热运行试验和特殊测量。

(6)After the (6)Heat Run Test and Special Measurements completed, Perform as Manual Tap Changer Step and Ground/Metallic Return Transfer described in section 4.2.3-4.2.4 at the power level 2000MW.

(6)在完成热运行试验和特殊测量后，按照 4.2.3-4.2.4节中所述的手动抽头切换开关步骤和接地/金属回路转移在2000MW的功率水平下进行。

(7)Ramp the power down to 200MW at 50MW/min rate in steps of 200MW with an interval of 2 min.The interval is to make sure the system is stable.

(7)以50MW/分钟的速度，以200MW的步长将功率降低到200MW，间隔2分钟。间隔是为了保证系统稳定。

(8)When Ramp power from 800MW to 600MW at 999MW/min ramp speed.

(8)当功率从800MW到600MW，斜坡速度为999MW/分钟时。

(9)Verify that the power reaches the reference value after ramping is completed and that the ramping process is smooth and without disturbances.

(9)验证斜坡完成后功率达到参考值，斜坡过程平稳且无干扰。

(10)Initiate a manual switchover from PCPA to PCPB and from PCPB to PCPA while ramp is in progress.

(10)当ramp正在进行时，启动从PCPA到PCPB以及从PCPB到PCPA的手动切换。

(11)Verify:

(11)验证:

3)the ramping process is smooth and continuous without transient changes in the power transmission.

3)斜坡过程是平滑和连续的，在功率传输中没有瞬时变化。

4)the references are fulfilled after the ramping is completed.

4)斜坡上升完成后，参考值被满足。

(12)Stop the pole.

(12)停止该极。

(13)Record and save test data

(13)记录并保存测试数据

**4.3.3 Tap Changer Control, Manual Tap Changer Step**

**4.3.3分接开关控制，手动分接开关步骤**

Notes: This test would be accomplished in parallel with 4.3.2.

注意:该测试将与4.3.2并行完成。

Matiari:

默蒂亚里:

(1)Set tap changer control in MANUAL CONTROL mode and decrease one steps for decreasing Udi0.

(1)将抽头切换开关控制设置为手动控制模式，并减少一个步长以降低Udi0。

(2)Verify increased firing angle and maintained transmitted current.

(2)验证增加的触发角和保持的传输电流。

(3)Set the tap changer control back to AUTO CONTROL mode.

(3)将抽头切换开关控制设置回自动控制模式。

(4)Verify that:

(4)验证:

1)The tap changer would automatically return to original position if the AC voltage remained unchanged.

1)如果交流电压保持不变，分接开关将自动返回到原始位置。

2)Firing angle back within control limits.

2)触发角回到控制范围内。

3)Maintained transmitted current.

3)保持传输电流。

LAHORE:

拉合尔:

(5)Set tap changer control in “MANUAL CONTROL”mode and decrease one steps for decreasing Udi0.

(5)将抽头切换开关控制设置为“手动控制”模式，并减少一个步长以降低Udi0。

(6)Verify:

(6)验证:

5)Decreased DC voltage

5)DC电压降低

6)Maintained gamma (γ) in LAHORE.

6)在拉合尔维持关断角。

7)Decreased tap position in Matiari to maintain firing angle within control limits.

7)降低默蒂亚里的抽头位置，以将触发角度保持在控制范围内。

8)Maintained transmitted current.

8)保持传输电流。

(7)Set the tap changer control back to “AUTO CONTROL”mode.

(7)将抽头切换开关控制设置回“自动控制”模式。

(8)Verify that:

(8)验证:

6)The tap changer would automatically return to original position if the AC voltage is unchanged.

6)如果交流电压不变，分接开关将自动返回到原始位置。

7)Firing angle back within control limits.

7)触发角回到控制范围内。

8)DC voltage back to nominal value.

8)DC电压回到标称值。

9)The tap position in Matiari is increased to maintain firing angle within control limits.

9)增加Matiari站的抽头位置，以将触发角度保持在控制范围内。

10)Maintained transmitted current.

10)保持传输电流。

(9)Record and save test data

(9)记录并保存测试数据

**5 Pole 2 Heat Run Test and Special Measurements**

**5极2热运行测试和特殊测量**

**5.1 Preconditions**

**5.1试验条件**

The test objective is to carry on heat run test and special measurement during high power test.

试验目的是在大功率试验时进行热运转试验和特殊测量。

**5.2 Preconditions**

**5.2试验条件**

(1)all low power tests have been finished.

(1)所有小功率测试已经完成。

(2)AC system precondition:

(2)交流系统试验条件:

1) The 500kV bus voltage of two AC systems is about 505~525kV.

1)两个交流系统的500kV母线电压约为505~525kV。

2)Both sides of AC system are capable to supply the power for the test.

2)交流系统的两侧都能够为测试供电。

(3)DC system precondition:

(3)DC体系的前提条件:

默蒂亚里:

[X]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[ ] Q控制 [X] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

拉合尔:

[ ]主控站

[X] 站控A值班 [ ] 站控 B值班

[X] 极控A值班 [ ] 极控 B值班

[X]正常功率传输方向[ ]反向功率传输方向

[X]有通信 [ ]无通信

[X]功率控制 [ ] 电流控制

[X]联合控制 [ ]独立控制

[X] 无功自动控制 [ ] 无功手动控制

[X] Q控制 [ ] U控制

[X]全压运行 [ ]降压运行

[X]大地回线 [ ]金属回线

**5.3 Test Content and Procedure**

**5.3测试内容和程序**

**5.3.1 Pole 2 Run at 1.00 p.u. in Monopole without Redundant Cooling**

**5.3.1极2以1.00pu单极运行，无冗余冷却**

Notes: The procedure (1) - (5) would be accomplished in parallel with 4.2.2-4.2.4.

注:程序(1) - (5)将与4.2.2-4.2.4并行完成。

(1)Before start of Heat Run Test, samples for DGA (Dissolved Gas Analysis) shall be taken from converter transformers.

(1)热运行试验开始前，应从换流变压器中提取DGA(溶解气体分析)样品。

(2)Switch RPC to“Q control”in both stations.

(2)将两个站的RPC切换到“Q控制”。

(3)Start the pole at minimum power in Normal Direction, metallic return operation,200MW (303A), ramp rate 100MW/min.

(3)以最小功率启动该极，正常方向，金属回线方式，200MW（303A），斜坡率100MW/min。

(4)Ramp the power up to 2000MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

(4)以50MW/分钟的速度，以200MW的步长将功率提升至2000MW，间隔2分钟，在每增加200MW之间保持稳定运行:

(5)Keep the pole in operation for 4 hours at 1.0 p.u. The following verifications should be carried during this period.

(5)保持该极在1.0 p.u .下运行4小时。在此期间应进行以下验证。

9)Verify that the reference is fulfilled after the ramping is completed.

9)验证斜坡完成后是否满足参考。

10)Verify that the measured currents and voltages at DC and AC side are correct.

10)验证DC和交流侧的测量电流和电压是否正确。

11)Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

11)连续读取并记录阀门冷却水入口和出口温度(本地和/或远程指示)，直到达到合理的稳定温度(温度应在大约15分钟内稳定)。

12)Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

12)每30分钟(本地和/或远程指示)读取并记录换流变压器和平波电抗器中线圈绕组和热点的温度，直到达到合理的稳定温度(温度应在大约3小时内稳定)。

13)Read 13)and record AC-side individual harmonics, D13)n13), total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

13)读取13)并记录交流侧单个谐波、Dn、总谐波失真、总谐波失真、电话谐波形状系数、总谐波频率，单位为默蒂亚里和拉合尔。

14)Read and record DC-side harmonics and Ieq in Matiari andLAHORE.

14)读取并记录默蒂亚里和拉霍尔的DC侧谐波和Ieq。

15)Perform special measurements as described in below section 5.3.3-5.3.6.

15)按照以下第5.3.3-5.3.6节所述进行特殊测量。

16)The Power Loss in Station should be measured by subtracting the DC power from the power flowing into the converter transformer.

16)站的功率损耗应通过从流入换流变压器的功率中减去DC功率来测量。

(6)Record and save all data.

(6)记录并保存所有数据。

(7)Keep pole running at 1.0 p.u. and proceed to the next item.

(7)保持该极以1.0 p.u .运行，并继续下一项。

**5.3.2 Pole 2 Run at 1.1 p.u. in Monopole with Redundant Cooling**

**5.3.2带冗余冷却的单极天线中的1.1功率单位的2极运行**

(1)Verify the pole 2 running at 1.0p.u. in metallic transfer return.

(1)在金属传送回路中，验证极2以1.0p.u. 运行。

(2)Ramp the power up to 2200MW at 50MW/min rate in steps of 200MW, with an interval of 2 min with stable operation in between each 200MW increase:

(2)以50MW/分钟的速度，以200MW的步长将功率提升至2200MW，间隔2分钟，在每增加200MW之间保持稳定运行:

(3)Keep the pole 2 in operation for 40 minutes at 1.1 p.u. The following verifications should be carried during this period.

(3)保持极2在1.1 p.u .下运行40分钟。在此期间应进行以下验证。

9)Verify that the reference is fulfilled after the ramping is completed.

9)验证斜坡完成后是否满足参考。

10)Verify that the measured currents and voltages at DC and AC side are correct.

10)验证DC和交流侧的测量电流和电压是否正确。

11)Read and record valve cooling water temperature inlet and outlet (local and/or remote indications) continuously, until reasonable stable temperature is reached (temperatures should be stable within approximately 15 minutes).

11)连续读取并记录阀门冷却水入口和出口温度(本地和/或远程指示)，直到达到合理的稳定温度(温度应在大约15分钟内稳定)。

12)Read and record temperature of coil winding and hot spot in converter transformer and smoothing reactor every 30 minutes (local and/or remote indications) until reasonable stable temperature is reached (temperatures should be stable within approximately 3 hours).

12)每30分钟(本地和/或远程指示)读取并记录换流变压器和平波电抗器中线圈绕组和热点的温度，直到达到合理的稳定温度(温度应在大约3小时内稳定)。

13)Read and record AC-side individual harmonics, Dn, total harmonic distortion, THD, Telephone Harmonic Form Factor, THFF, in Matiari and LAHORE.

13)读取并记录交流侧单个谐波、Dn、总谐波失真、总谐波失真、电话谐波形状系数、总谐波频率，单位为默蒂亚里和拉合尔。

14)Read and record DC-side harmonics and Ieq in Matiari and LAHORE.

14)读取并记录默蒂亚里和拉合尔的DC侧谐波和Ieq。

15)Perform special measurements as described in below section 5.3.3-5.3.6.

15)按照以下第5.3.3-5.3.6节所述进行特殊测量。

16)The Power Loss in Station should be measured by subtracting the DC power from the power flowing into the converter transformer.

16)站的功率损耗应通过从流入换流变压器的功率中减去DC功率来测量。

(4)Ramp the power down to 2000MW (3030A), at 50MW/min

(4)以50MW/min的速度将功率降低至2000MW (3030A)

(5)Record and save all data.

(5)记录并保存所有数据。

**5.3.3 Radio Interference Measurements**

**5.3.3无线电干扰测量**

To check if the radio and television interference generated by the HVDC plant is within the specified limit at the specified locations.

检查高压直流输电设备产生的无线电和电视干扰是否在指定位置的指定范围内。

(1)Choose 1 or 2 test places inside the converter stations and about 450m away outside the converter station and carry out the measurement of the interference frequency (1)spectrum(1).

(1)在换流站内和换流站外约450米处选择1或2个测试地点，进行干扰频率(1)频谱(1)的测量。

(2)To measure the frequency spectrum characteristics of radio interference under the outlet line of the 660 kV valve hall and at 20 m from the outlet line inside the converter station.

(2)测量660kV阀厅出线下和换流站内出线20 m处的无线电干扰频谱特性。

(3)Record and save all data.

(3)记录并保存所有数据。

**5.3.4 Audible Noise Check**

**5.3.4声音噪音检查**

To check if the audible noise level, generated by the HVDC plant, is within the specified limits at specified locations.

检查确切区域的高压直流输电设备产生的可听噪声水平在指定限值内。

(1)Measurement of Audible noise near the convertor transformer in the converter station.

(1)测量换流站换流变压器附近的可听噪声。

(2)Measurement of Audible noise along the boundary line outside the converter station.

(2)测量换流站外边界线上的可听噪声。

(3)Measurement of Audible noise in front of the houses near the converter station, if there are houses.

(3)测量换流站附近房屋前的可听噪声(如果有房屋)。

(4)Record and save all data.

(4)记录并保存所有数据。

**5.3.5 Station Service Power Losses**

**5.3.5电站服务功率损失**

The aim of this test is to determine the losses of the auxiliary supply under load and no-load conditions.According to the study report, only the critical and essential loads of the equipment supplied are included.

该测试的目的是确定负载和空载条件下辅助电源的损耗。根据研究报告，仅包括所提供设备的临界和基本负荷。

(1)In status Ready for Operation, the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour).The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed losses.

(1)在状态准备运行中，在一个预定的时间段内测量400伏功率水平上的负载(例如，一小时内测量5次)。对测量结果进行平均，得到与空载或固定损耗相当的损耗值。

(2)Verify that these measured loss values should be within limited value specified by technical specification.

(2)验证这些测量的损失值应在技术规范规定的限值内。

(3)When the pole 2 is in operation at 1.0 p.u. or 1.1 p.u., the loads on the 400V power level are measured within one scheduled time period (for example 5 times measurements in one hour).The measurement results are averaged to get values, which are equivalent losses to the no-load or fixed (3)losses.

(3)当极2在1.0Pu或1.1Pu下运行时，在一个预定的时间周期内测量400伏功率水平上的负载(例如一小时内测量5次)。对测量结果进行平均，得到与空载或固定损耗相等的值。

(4)Record and save all data.

(4)记录并保存所有数据。

**5.3.6 Temperature Measurement With IR-Camera Equipment**

**5.3.6用红外摄像设备进行温度测量**

(1)Verify by use of IR-camera that the temperature of busbars, clamps conductors, equipment, etc.are acceptable in DC-yard, AC-yard, and valve hall.

(1)使用红外测温仪确认直流场、交流场以及阀厅等区域的母线、夹具导体等设备的温度正常。

(2)Record and save all data.

(2)记录并保存所有数据。

**6 Safety measures and special points for the station tests**

**6系统调试A全措施和特点**

**6.1 For HVDC system**

**6.1对于高压直流输电系统**

(1)All personnel who take part in the test shall follow all the safety regulations for the electrical works strictly.

(1)所有参加试验的人员应严格遵守电气工程的所有A全规定。

(2)In the station a qualified engineer should be appointed as a test leader from the Owner, who shall be a coordinator with CEPRI commissioning engineers.

(2)在换流站中，应由业主任命一名合格的工程师作为调试负责人，该负责人应是CEPRI调试工程师的协调员。

(3)In the station, qualified technicians from the Owner, the assembly companies or the manufacture companies with mobile phone have to be appointed to watch the equipment in AC yard, in DC yard and in valve hall separately when a test proceeds.They ought to report immediately to the test leader as they find any abnormality or fault of the equipment.

(3)在站内，当调试进行时，必须指定来自业主、施工单位或设备单位合格技术人员分别在交流场、直流场和阀厅观察设备，通过移动电话通信。当他们发现设备的任何异常或故障时，应立即向调试负责人报告。

(4)No person is allowed to enter into the test area without permission.

(4)未经许可，任何人不得进入试验区。

(5)All the high voltage area shall be isolated with closed fence and a notice board with “HV DANGER!”should be put on it.

(5)所有高压区域应使用封闭的围栏和带有“高压危险”的警示牌进行隔离。

(6)In the station, an emergent maintenance team with mobile phone shall be ready for any repair or inspection work when needed.

(6)在站内，当需要维修或检查工作时，应有一支配备手机的紧急维修队伍。

(7)Only the personnel with the test identity are allowed to enter the test area.

(7)只有具有测试身份的人员才允许进入测试区域。

(8)The qualified operators are only allowed to carry out the operation.

(8)只有合格的操作人员才能进行操作。

(9)All the operations shall be done strictly according to the Operation Instructions.

(9)所有操作应严格按照操作说明进行。

(10)The temporary test wiring and maintenance of main circuit equipment in site and control & protection cubicles should be proceeded and corresponding safety measures should be carried out by the qualified personnel under the supervision of qualified specialists.

(10)现场主电路设备和控制保护柜的临时试验接线和维护应由合格人员在合格专家的监督下进行，并采取相应的A全措施。

(11)The test wiring to control or protection cubicles shall be demonstrated and supervised by qualified specialists.

(11)控制或保护柜的测试接线应由合格的专家进行演示和监督。

**6.2 For AC system**

**6.2对于交流系统**

All the regulations and safety measures for the AC system operation have to be followed strictly.

必须严格遵守空调系统运行的所有规定和A全措施。

**7 Annex**

**7附件**

HVDC - High Voltage Direct Current

HVDC -高压直流

DC - Direct Current

DC -直流

AC - Alternative Current

AC -交流电流

CEPRI - China Electric Power Research Institute

中国电力科学研究院

TFR - Transient Fault Recorder

TFR瞬态故障记录器

PCP - Pole Control & Protection

PCP-极控制和极保护

SCM - SCADA and Monitoring

站控监视系统

SC - Station Control

站控

RPC - Reactive Power Control

无功功率控制

DGA - Dissolved Gas Analysis

DGA -溶解气体分析

IR Camera - Infrared Camera

红外照相机-红外照相机

Dn - Individual Harmonics

单个谐波

THD - Total Harmonic Distortion

总谐波失真

THFF - Telephone Harmonic Form Factor

电话谐波形状因子

IEQ - Equivalent Interference Current

IEQ等效干扰电流

MRTB - Metallic Return Transfer Breaker

MRTB -金属回路转换断路器

GRTS - Ground Return Transfer switch

GRTS -接地回路转换开关

NBGS - Neutral Bus Ground Switch

NBGS -中性母线接地开关