IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Procedure, Check List and Record Format of Trouble-Free Commissioning of Electro-Mechanical Equipment for Airport and Datacentre Projects

Prasun Ghatak[1]

Commissioning Manager, Building & Factories, L&T Construction, Hyderabad, India[1]

Abstract: The fault free operation of major MEP equipment i.e. HT Switchgear, Transformer, Panels, Chiller, Cooling Tower, Pumps, AHUs, Fans are required for sophisticated Airport and Data Centre. Commissioning is the only phase where we identify all the design, quality, transportation and installation faults before handing over to operation team. In this paper, various intelligence techniques, past experience and learnings are used to commission and trial run of electro-mechanical equipment. This study focuses on making easy formats for trouble free commissioning within stringent timeline.

Keywords: Testing, Commissioning, Water Cooled Chiller, AHU, Cooling Tower, Pump, Ventilation Fans.

I. INTRODUCTION

The M-E-P in MEP are as follows:
M- The mechanical design elements of a premises, most especially the heating and cooling systems, help make life inside more comfortable. These systems allow us to occupy buildings in hot and cold temperatures, under all weather conditions.
E- The electrical system in a premises keeps the lights on, keeps our devices powered, and keeps the other systems running. Transformer and Switchgear are crucial components of the electrical engineering process.
P- Water is what sustains us. Plumbing systems provide fresh water for drinking, cleansing and more. And they take storm and sanitary wastewater away, safely.

Commissioning is a systematic process of ensuring, verifying and documenting performance of systems in accordance with the design intent, contract documents, and the owner's operational needs.

II. WATER COOLED CHILLER

2.1 Pre-start-up check

Procedure:

Inspections that need to be carried out prior to commissioning includes:

1. Confirm if all normally open valves are in open position & normally closed valves are in closed position.
2. Clean and clear off any debris within the starter compartment.
3. Check desired capacity pumps are available that would provide adequate amount of water flow rate to Chiller unit.
4. Start the chilled water and condenser water pumps. Check the water pressure drop across evaporator & condenser shell as compare to design
5. If desire pressure drop cannot be achieved, advise relevant party to look into the system.
6. Ensure chilled water and condenser water flow rates are adjusted using electric controlled valves and the system is balanced.
7. Check the safety devices, such as flow switches of chilled and condenser water piping are operating properly.
8. Ensure adequate time is given to allow compressor lubricated oil to achieve operating temperatures.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Record format:

Inspection	Yes	No	NA
Confirm if all normally open valves are in open position & normally closed valves are in closed position			
Check pumps are available & running to provide adequate volume to Chiller			
CHW pressure drop across evaporator is within acceptable limit			
CW pressure drop across condenser is within acceptable limit			

2.2 Chiller Startup Check

Procedure:
Measure basic electrical parameters (i.e. voltage/current/power consumption) for chiller unit. Note down the results in electrical section below and cross verify the results against approved Chiller technical datasheet.
Note: Do not start Chiller if voltage imbalance is greater than 2%.

Below minimum parameters shall be verified for Starter & Control Panel:
□□Check the tightness of the control wiring termination.
□□Check starter panel cable termination sequence as per approved wiring diagram.
□□Turn ON main power and check phase sequence.
□□Wait for 24 hours to heat up compressor oil or heat up at least to minimum 60°C
□□Check chiller control software, upgrade is necessary.
Note: Ensure Cooling tower, condenser, chilled water pump is running. Check the flow status of condenser and evaporator on the chiller "Mimic Display".

Record format:

Description	Units	Results		
Electrical Parameters Check				
Power Voltage	L1-L2 (V) L1-L3 (V)			
	L2-L3 (V)			
Average Voltage	(V)			
Maximum deviation from average voltage	(V)			
Voltage imbalance [(Max deviation /average voltage) x 100]	%			
Is voltage imbalance less than 2%		**Yes**	**No**	**NA**
Frequency	Hz			
Power Factor				
Compressor Inrush Current	(A)			

Note: Do not start Chiller if voltage imbalance is greater than 2%.

2.3 Chilled Water Section Parameters Verification

Procedure:
Verify chilled water parameters like CHW flow rate & CHW inlet/ outlet temperature and make sure the observed values are as per design requirement.

Record format:

Description	Units	Results
CHW Pump Reference No.		
CHW Pump Serial No.		
Chilled Water Flow Rate	L/s	
Entering Water Temperature	Deg C	
Leaving Water Temperature	Deg C	

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Evaporator Inlet Pressure	KPa	
Evaporator Outlet Pressure	KPa	
Evaporator Pressure Drop	KPa	

2.4 Condenser Water Section Parameter Verification

Procedure:

Verify condenser water parameters like CW flow rate & CW inlet/ outlet temperature and make sure the observed values are as per design requirement.

Record format:

Description	Units	Results
CW Pump Reference No.		
CW Pump Serial No.		
Condenser Water Flow Rate	L/s	
Entering Water Temperature	Deg C	
Leaving Water Temperature	Deg C	
Condenser Inlet Pressure	KPa	
Condenser Outlet Pressure	KPa	
Condenser Pressure Drop	KPa	

2.5 Compressor Section Parameters Verification

Procedure:
Verify compressor parameters like discharge pressure, oil pressure, discharge temperature etc. and make sure the observed values are within OEM's operating conditions.

Record format:

Description	Units	Results
Discharge Pressure	PSIG	
Oil Pressure	PSIG	
Evaporator Pressure	PSIG	
Oil Sump Temperature	oF	
Discharge Gas Temperature	oF	
Saturated Condensing Temperature	oF	
Percentage Full Load	Amps	

2.6 General Alarm Check

Procedure:

Check and simulate various alarms for chiller unit like low discharge temperature & high discharge temperature for compressor, evaporator low pressure, condenser high pressure, flow switch alarm etc. and cross verify if necessary alarms are reflected on units display.

Record format:

Inspection	Yes	No	NA
Low Discharge Temperature Alarm			
High Discharge Temperature Alarm			
Evaporator Low Pressure Alarm			
Condenser High Pressure Alarm			
Chilled Water Flow Switch Alarm (No Flow / Low flow Alarm)			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Condenser Water Flow Switch Alarm (No Flow / Low flow Alarm)			
Condenser Pressure Transducer out of range			
Control Panel Power Failure Alarm			
Oil Differential Pressure High Alarm			
Oil Differential Pressure Low Alarm			

2.7 Sensor Calibration Checks

Procedure: Measure and record various parameters like CHW/ CW inlet temperature, CHW/ CW outlet temperature etc. and cross validate the parameter values from Chiller display. OEM to calibrate the necessary sensor/ transducers if discrepancies are observed in above recorded values.

Record format:

Description	Unit	Display	Measured
CHW Entering Temperature			
CHW Leaving Temperature			
CW Entering Temperature			
CW Leaving Temperature			

2.8 BMS Integration Check

Procedure: Ensure the BMS communication protocol is as per design requirement. All the low level & high level BMS integration points shall be cross validated as per approved IO list as per design requirement.

Record format:

Point description	Field status			BMS status		
	Yes	No	N/A	Yes	No	N/A

2.9 Noise Level Check

Procedure: Noise level check for Chiller shall be carried out using DB meter.

Record format: The following data shall be recorded during Chiller acoustic test.

Sl. No.	Reference point	Sound Level (dB)	Average Sound Level (dB)

2.10 Auto Restart Functional Check

Procedure:
Check the Auto restart function of Chiller by switching off and successively switching on its incomer breaker. Ensure Chiller gets automatically Switched On as per unit set delay.

Record format:

Description	Results		
	Yes	No	N/A
Verify Auto Restart of Chiller Unit			
Verify Immediate Emergency Stop operation			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

2.11 Response to Remote Start/ Stop Signal

Procedure: This test involves integration between chiller controller & 3rd party (BMS). The proposed test procedures include;

a. Ensure the communication protocol (between chiller & BMS) had been established prior the test.
b. An external "Start" signal is transmitted to the chiller.
c. Check & verify that the chillers are operating.
d. Repeat step (b) to (c) by sending an external "Stop" signal to the chiller.

Record format:

Sl. No.	Description	Results		
		Pass	Fail	N/A
1	Check and ensure chiller is not running			
2	Send an external 'start' signal to the chiller. Check and ensure the chiller is Running.			
3	Send an external 'stop' signal to the chiller. Check and ensure the chiller stop running			

Pre-Test Condition: The chiller must be switched-off by opening its incomer breaker before proceeding to remote start/ stop signal check.

2.12 Remote Temperature Setpoint Adjustment

Procedure:
This test involves integration between chiller controller & 3rd party (BMS). The proposed test procedures include;
a. Ensure the communication protocol (between chiller & BMS) had been established prior the test.
b. An external high level signal controlling chillers set point is transmitted to the chiller.
c. Check & verify the temperature set point had been adjusted at chiller control panel (MIMIC Display).

Record format:

Description	Results		
	Pass	Fail	N/A
Send an external high level 'temperature setpoint' signal to the chiller. Check and ensure the temperature setpoint has been adjusted at chiller control panel.			

2.13 Chiller Functional Test Trends

Procedure: The functional test shall be carried out for design setpoint of 130C @ Available Load for a period of minimum 4 hours. The parameters shall be recorded in the form of trends. Trends shall be captured for every minute. Tick on the parameters that are kept trending during Chiller functional test.

Record format:

Description	Units	Trend Captured		
		Yes	No	N/A
CHW Flow Rate	L/s			
CHW Set point	Deg C			
CHW Supply Temperature	Deg C			
CHW Return Temperature	Deg C			
CW Flow Rate	L/s			
CW Supply Temperature	Deg C			
CW Return Temperature	Deg C			
Outdoor Temperature	Deg C			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Compressor % Loading	%			
Total Current Consumption	A			
Trending Time	Minutes			

2.14 Chiller Restart Time Check

Procedure: The chiller must be switched-off by opening its incomer breaker before proceeding to chiller restart time check. Now switch on the chiller by closing its incomer isolator and measure the time taken by chiller to reach its maximum capacity at available load.

Record Format:

Pre-Test Condition: The chiller must be switched-off by opening its incomer breaker before proceeding to chiller restart time check.

Description	**Results**		
	Yes	**No**	**N/A**
Switch On the chiller by closing its incomer breaker			
Measure the time (in seconds) taken by compressor to Switch On			
Measure the time (in seconds) taken by compressor to reach it maximum capacity at available load			

III. COOLING TOWER

Procedure:

3.1 Mechanical Checks

1. Check levelling and alignment of units are correct and acceptable.
2. Check adequate maintenance access has been provided for equipment.
3. Confirm all transit bolts, wedges etc. have been removed from Fan and Motor's isolation mountings and that they are free to move.
4. Confirm that fills and eliminator are free of damage / blockage.
5. Check make-up water supply is available to equipment and confirm with the
6. Cooling tower have sufficient water.
7. Confirm all electrical connections are securely tightened.
14. Megger Test motor windings to confirm no low readings or short circuit.

3.2 Cooling Circuit Check

1. Confirm condenser water circuit is operating and that the water flow is available to the cooling tower.
2. Confirm condenser water system has been hydrostatically tested and that there is no evidence of leakage at joints or valves.
3. Confirm that vents are installed at the highest point of the pipework and a drain has been installed at the lowest point of equipment.
4. Confirm condenser water system has been flushed and cleaned.
5. Confirm cooling circuit has been vented of all air.
6. Confirm the condensing water pump commissioning test is complete.

3.3 Water Basin Check

1. Check the water basin of cooling tower is fully filled with water and verify that the drain pipe is connected properly.
2. Set / calibrate operation of Ball valve / float valve to each cooling tower to prevent any overflow or underflow during cooling tower operation.
3. Confirm there are no leaks from the cooling tower basin joints.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

3.4 Start-up test

1. Start – stop the fan to verify the direction of rotation
2. Check to ensure no water leakage below water basin area
3. Check to ensure no water leakage between basin and casing joints
4. Measure voltage and the current on all three power leads. The current must not exceed the motor name plate full load amp rating
5. Measure the vibration level at cooling tower vertical and horizontal panels. The vibration shall not exceed the limit of 7.1 mm/s RMS
6. Measurement of water flow rate by referring to Condenser water pumps flow meter.
7. Monitor basin water level during operation
8. Check make-up water line during normal operating condition
9. Adjust the mechanical float valve, if required
10. Check drift eliminators during normal operating condition
11. Check water distribution system and spray pattern
12. Fan motor cycling – controls should be set to only allow a maximum of six (06) start/stop cycles per hour for each motor
13. Fan system is recommended to speed up and slow down uniformly. Ramp-up and ramp-down time should be approximately 120 secs

3.5 Functional Test

1. With all related equipment operating in normal condition (chiller, Chilled water pump, condensing water pump and chemical dosing system) allow time to stabilize and confirm equipment controls to supply the condenser water at its set point temperature.
2. Record all test information on test sheets.

With equipment operating in normal conditions undertake the following functional checks and performance tests:

- Condensing Water Flow Rate in Full Flow Condition
- Condensing Water Supply Temperature.
- Condensing Water Return Temperature.
- Measure & record the Air flow rate of the cooling tower.
- Measure & record the water flow rate of the cooling tower.
- Air Temperatures on both sides of cooling tower fill.
- Outdoor temperature

3.6 BMS Integration Check

Ensure the BMS communication protocol is as per design requirement.
All the low level & high level BMS integration points shall be cross validated as per approved IO list as per design requirement.

Record format:

3.7 Electrical Check

Inspection	Yes	No	NA
Confirm starter timers setting are correctly set and VSD parameters have been programmed.			
Upper frequency limit set at 100%			
Min. speed setting acceptance: <50% or 30 Hz			

3.8 Motor Insulation Test

Sl. No.	Insulation Resistance	Applied Test Voltage	Measure Value (MΩ)
1	L1-L2		
2	L2-L3		
3	L1-L3		

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

4	L1-G		
5	L2-G		
6	L3-G		

3.9 Startup Check

Inspection	Yes	No	NA
Ensure correct Phase Sequence Of Incoming Source			
Check drift eliminators operating condition.			
Check direction of rotation of fan.			
Check water distribution system and spray pattern			
Check operating water level in basin and adjust make-up float valve			
Check inlet, outlet valves for full open position			
Check all drain valves for full close position			
Check make-up water line in normal operating condition			
Check water leaks visually, below the water basin area			
Check water leaks visually, between basin and casing joints.			
Check for abnormal / excessive operation noise and vibration.			
Check and monitor the basin water level during operation			
Fan start delay			

3.10 Power/ Voltage / Operating Current

Description	Units	Expected	Actual
Voltage	L1-L2 (V)		
	L1-L3 (V)		
	L2-L3 (V)		
Running Current:			
Fan 1 Motor	L1 (A)		
	L2 (A)		
	L3 (A)		
Power	KW		
Fan 2 Motor	L1 (A)		
	L2 (A)		
	L3 (A)		
Power	KW		
Fan 3 Motor	L1 (A)		
	L2 (A)		
	L3 (A)		
Power	KW		
Fan 4 Motor	L1 (A)		
	L2 (A)		
	L3 (A)		
Power	KW		

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

3.11 Water Flow Measurement

Description	Units	Expected	Actual
Condenser Water Flow Rate	***L/s***		

3.12 Air Flow Measurement

Description	Units	Expected	Actual
Face 1 Airflow Rate	L/s		
Face 2 Airflow Rate	L/s		
Face 3 Airflow Rate	L/s		
Face 4 Airflow Rate	L/s		
Total Airflow Rate	L/s		

3.13 Noise Level

Description	Units	Expected	Actual
Noise Level of Cooling Tower @ 1 meter			

3.14 Performance Test

Description	Units	Expected	Actual
Air Side Checks			
Entering Dry Bulb Temperature	0C		
Entering Wet Bulb Temperature	0C		
Leaving Dry Bulb Temperature	0C		
Leaving Wet Bulb Temperature	0C		
Measured Airflow Rate	L/s		
Water Side Checks			
Condenser Water Flow Rate	L/s		
Condenser Water Entering Temperature	0C		
Condenser Water Leaving Temperature	0C		
Calculated Heat Rejection			
Air Side (mCpΔT)	kW		
Water Side (mCpΔT)	kW		

3.15 Control Checks

Description	Pass	Fail	NA
Verify Manual Switch Operation Pass Fail N/A Pass Fail N/A			
Verify Auto Switch Operation			
Verify OFF Switch Operation			
Simulate a Fan Failure scenario and command the cooling tower to Start			
Verify the Fan speed modulate via VFD to maintain constant condenser supply water temperature. Simulate 3-4 scenarios by varying the condenser water temperature & verify Fan speed			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

IV. AIR HANDLING UNIT (AHU)

Procedure:

4.1 Air Side Checks

1. Start the AHU
2. Run fan & motor to ensure correct operation and speed
3. Measure and record the AHU fan volume to verify correct air flow rate is being achieved at the design operating speed.
4. Measure and record the motor running current on all phase.
5. Measure and record down the suction & discharge pressure of the AHU.

4.2 Water Side Checks

1. Start up the AHU with design speed.
2. Regulate the chilled water flow to the cooling coil of the unit and record down the water pressure drop data across the coil at designed water flow rate;
3. Confirm correct chilled water flow rates and supply temperatures for the AHU cooling coil;
4. Measure and record down the chilled water in / out temperature for the AHU cooling coil.
5. Measure and record down the chilled water in / out water flow rate for the AHU cooling coil.
6. Measure and record down the AHU supply / return air dry bulb and wet bulb temperature.

4.3 Control Panel Checks

1. Test the E-stop function is properly.
2. Test the thermal overload tripping function.
3. Test the AHU Control Panel function.
4. Start the AHU and after the AHU in running, test the fire tripping signal by disconnect the inter-link at fire alarm interfacing contact at the Control Panel.
5. Reset the fire trip signal by install the fire alarm inter link.
6. Before start up the AHU, check that the supply motorize damper is fully closed.
7. Test the supply motorize damper by “manual” and start the AHU and check the motorize damper is being fully opened.
8. Test the supply motorize damper by “Auto” and start the AHU and check the supply motorize damper is being fully opened.

4.4 Sensor Calibration Checks

Measure and record Return air temperature values. Record return air temperature readings from BMS temperature sensor. Ask OEM to calibrate the return air Temperature sensor if discrepancies are observed in above recorded values.

Follow the same procedure for calibrating Supply air temperature sensor.

4.5 AHU Functional test

The Functional test of AHU needs to be carried out as follows.

- Check the Auto restart function of AHU by switching off & again switching on its incomer breaker.
- Verify the operation of AHU motorized damper based on AHU manual Start and Stop. The Motorized damper shall open once AHU starts and shall Close once AHU stops.
- Verify the time sequencing between AHU by checking the AHU standby-working rotation.
- Verify the Failure sequencing of AHU by switching off the working AHU unit and check whether the standby AHU unit gets switches on.
- Verify the high temperature sequencing of AHU unit by simulating a high temperature scenario. Check whether the standby AHU unit switches on under this circumstance.
- Verify the 2 way control valve operation based on room temperature.
- Verify the VFD operation for both Auto and Manual mode.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

4.6 Noise Level Check

Noise level check for AHU unit shall be carried out using DB meter. Switch on AHU unit and note down the noise level by holding the DB meter 1 meter away from AHU unit. Ensure the measure dB level is within the acceptable limit and less than the noise level specified in approved AHU technical data sheet.

4.7 BMS Integration Check

Ensure the BMS communication protocol is as per design requirement. All the low level & high level BMS integration points shall be cross validated as per approved IO list as per design requirement.

Record format:

4.8 Pre Startup Check

Inspection	Yes	No	NA
Ensure all terminals has been tightened properly			
Ensure all system are in Auto mode			
Min. speed setting acceptance: <50% or 30 Hz			

4.9 Control Panel Check

Inspection	Yes	No	NA
Start AHU by Switching On Incomer MCB			
Check Mains phase rotation			
Check mains L-L Voltage			
Check proper operations of LMCP Push Buttons			
Check proper operation of LMCP Selector Switch			
Check LMCP Manual operation of motor on Bypass Mode			
Check LMCP Manual operation of motor on VFD Mode			
Check indication lamps operation			
Check manual ramp up & ramp down of Fan via VFD			

4.10 Electrical Parameters @ 50 Hz VFD mode

Description	Units	Expected	Actual
Voltage	L1-L2 (V)		
	L1-L3 (V)		
	L2-L3 (V)		
Current	L1 (A)		
	L2 (A)		
	L3 (A)		
Voltage (Avg)	(V)		
Power factor			
Power	kW		

4.11 Electrical Parameters @ Bypass mode

Description	Units	Expected	Actual
Voltage	L1-L2 (V)		
	L1-L3 (V)		

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

	L2-L3 (V)		
Current	L1 (A)		
	L2 (A)		
	L3 (A)		
Voltage (Avg)	(V)		
Power factor			
Power	kW		

4.12 Water Side

Description	Units	Actual	Expected
CHW Flow Rate	L/s		
CHW Inlet temperature	Deg C		
CHW Outlet Temperature	Deg C		

4.13 Air Side

Description	Units	Actual	Expected
Airflow Rate	L/s		
Supply Air temperature	Deg C		
Return Air Temperature	Deg C		

4.14 Airflow Measurement

Traverse Units (m/s)						Avg Velocity (m/s)	Measured Airflow (L/s)	Design Airflow (L/s)	% Design
Vane Anemometer Readings @ 100% Speed									

Area (m2):

4.15 Sensor Calibration:

Description	Units	Display	Actual
Return Air Temperature	Deg C		
Supply Air temperature	Deg C		

4.16 AHU Functional Test

Description	Pass	Fail	N/A
Auto Restart: Switch Off the power supply to AHU and again restore the power supply. Verify AHU automatically restarts once power supply is restored.			
Time Sequencing: Note down the no. of AHU working and no. of AHU Standby as per design requirement.			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Time Sequencing: Verify the Auto rotation of AHU's from working to Standby model and vice versa as per the set time.			
Failure Sequencing: Verify the Auto activation of Standby AHU by manually failing one working AHU (Scenario 1).			
Failure Sequencing: Verify the Auto activation of Standby AHU by manually failing one working AHU (Scenario 2).			
High Temperature Standby Activation: Simulate a high temperature scenario and verify the Auto activation of Standby Unit.			
2 Way Control Valve: Verify the modulation of 2 Way control valve based on room temperature sensor.			
VFD Operation: Verify the VFD Operation in Auto mode			
VFD Operation: Verify the VFD Operation in Manual mode			

4.17 Noise Level Check

Description	Expected	Measured
Noise Level @ 1 meter away from unit		

V. PUMP

Procedure:

5.1 Pre-Test Condition

Inspections that need to be carried out prior to the test include but not limited to;
1. Confirm if all normally open valves are in open position & normally closed valves are in closed position.
2. Check water available at Pump.
3. Check power supply available at the incoming of Pump LCP and verify the voltage and Phase sequence.

5.2 Initial Start Checks

1. Fully close the pump discharge valve, record down the pump shut off pressure and then open the pump discharge valve.
2. Test the pump by using the pump by-pass starter, Start Delta or DOL starter. On activating the motor starter at initial start, check that:

a. The direction and speed of rotation of the motor shaft are correct.
b. The motor, pump, and drive are free from vibration and undue noise.
c. The sequence timing adjustment of star-delta starters (≥10s) is set in line of motor starting current.
d. The motor running current on all phases are balanced and do not exceed motor nameplate rating
e. The discharge valve can be opened slowly and monitoring the pump running current is not over of the pump name-plate full load current.
f. Record the pump running current, voltage, suction/ discharge pressure and plot the pump flow rate from the pump performance curve.
g. There is no overheating of the motor.
h. There is no seepage of the lubricant from the housing.
i. The ventilation systems of air-cooled motors are operating correctly.
j. The motor running current are correctly matching with the speed as specified by manufacturer.
k. For the pumps with VFD test the pump running at below item 12 to 16
l. After tested the pump by-pass starter, test the pump with VFD control.
m. The VFD setting and all functional should be checked and tested. The VFD setting is at minimum of 30 Hz and maximum of 50 Hz.
n. Run the pump with at maximum 50Hz, record the pump running current, voltage, input power factor, input harmonic at different running frequency.
o. Check the pump flow rate by record the pump suction / discharge pressure at different running
p. Frequency and plot the pump flow rate from the pump performance curve.
q. Check the motor, pump and drive are free from vibration and undue noise.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

5.3 Initial Run

1. Ensure that a light load should be sustained
2. Check and record the pump motor current reaches either the design value or the motor full load current, whichever is the lower and record the pump suction/ discharge pressure.
4. Check the pump pressure developed by means of the pump altitude gauges against the design pressure. If excessive pressure is developed at this stage, the cause should be investigated and rectified.
5. If all normal, run the pump under continuous observation.

5.4 Pump Functional test

The Functional test of Pump needs to be carried out as follows.

- Check the Auto restart function of Pump by switching off & again switching on its incomer breaker.
- Verify the VFD operation for both Auto and Manual mode.
- Verify the Emergency Stop operation of Pump.

5.5 BMS Integration Check

Ensure the BMS communication protocol is as per design requirement. All the low level BMS integration points shall be cross validated as per approved IO list as per design requirement.

Record format:

5.6 Pre Startup Check

Inspection	**Yes**	**No**	**NA**
Confirm if all normally open valves are in open position & normally closed valves are in closed position.			
Check water available at Pump			
Check power supply available at the incoming of Pump LCP and verify the voltage and Phase sequence			

5.7 Pump Running Frequency @ 50 Hz

Description		**Units**	**Expected**	**Actual**
Volumetric Flow Rate		L/s		
Voltage		L1-L2 (V)		
		L1-L3 (V)		
		L2-L3 (V)		
At Design / Max running current of motor, Full open pump head (kPa)	Current	L1 (A)		
		L2 (A)		
		L3 (A)		
	Suction	(m)		
	Discharge	(m)		
Voltage (Avg)		(V)		
Pump Operating Head		(m)		
Pump Shut Off Head		(m)		
Fluid Type		H2O		

5.8 Pump Running Frequency @ 30 Hz

Description		**Units**	**Expected**	**Actual**
Volumetric Flow Rate		L/s		

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

Voltage			L1-L2 (V)		
			L1-L3 (V)		
			L2-L3 (V)		
At Design / Max running current of motor, Full open pump head (kPa)	Current		L1 (A)		
			L2 (A)		
			L3 (A)		
	Suction		(m)		
	Discharge		(m)		
Voltage (Avg)			(V)		
Pump Operating Head			(m)		

5.9 Control Panel

Description	Pass	Fail	N/A
Power Healthy indication Lamps (L1/L2/L3)			
Check Running Indication Lamps			
Check Fault Indication Lamps			
Check Motor Start push button			
Check Motor Stop push button			
Check Lamp Test push button			
Check Auto / Off / Manual Switch operation			
Check VFD / Bypass Switch operation			

5.10 VFD

Description	Record		
Motor kW Setting			
Full Load current Setting			
Motor Voltage Setting			
Maximum Operating frequency setting			
Minimum Operating frequency setting			
Ramp up Time setting			
Ramp down Time setting			
VFD Display and control button is normal operation	Yes	No	N/A
VFD Ventilation operating in normal condition	Yes	No	N/A

5.11 Pump Functional Test

Description	Results		
	Pass	Fail	N/A
Auto Restart: Switch Off the power supply to Pump and again restore the power supply. Verify Pump automatically restarts once power supply is restored.			
Verify Emergency Stop Functional Test			
Verify Thermal Overload Functional Test			
VFD Operation: Verify the VFD Operation in Auto mode			
VFD Operation: Verify the VFD Operation in Manual mode			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

VI. DIESEL ENGINE DRIVEN PUMP

Procedure:

6.1 Pre-Test Condition

Inspections that need to be carried out prior to the test include but not limited to;
1. Confirm if all normally open valves are in open position & normally closed valves are in closed position.
2. Check water available at Pump.
3. Check power supply available at the incoming of Pump LCP and verify the voltage and Phase sequence.
4. Ensure sufficient amount of fuel is available for diesel engine.
5. Ensure the cooling water system is operational.
6. Ensure the flue exhaust system is operational.

6.2 Initial Start Checks

Test the pump by using the automatic diesel engine control panel. On activating the pump engine at initial start, check that;
1. The direction and speed of rotation of the engine shaft are correct
2. The engine, pump, and drive are free from vibration and undue noise
3. Record the pump suction & discharge pressure.
4. Measure the water flow rate using appropriate water flow measuring device.
5. Ensure there is no overheating of the engine.
6. Check the pump pressure developed by means of the pump altitude gauges against the design pressure. If excessive pressure is developed at this stage, the cause should be investigated and rectified.

6.3 Pump Functional test

The Functional test of Pump needs to be carried out as follows.
- Verify the Emergency Stop operation of Pump.
- Verify the pump kicks-in once the pressure in system is reduced to 4 bar.
- Ensure there is no cut-off set point for diesel engine pump & the pump needs to be switched off manually once started.

6.4 BMS Integration Check

Ensure the BMS communication protocol is as per design requirement. All the low level BMS integration points shall be cross validated as per approved IO list as per design requirement.
Record format:

6.5 Pre Startup Check

Inspection	Yes	No	NA
Confirm if all normally open valves are in open position & normally closed valves are in closed position.			
Check Chilled / Condenser water available at Pump			
Check power supply available at the incoming of Pump LCP and verify the voltage and Phase sequence is correct			
Confirm integration of Diesel Engine Pump with BMS System completed			
Ensure sufficient amount of fuel is available for diesel engine			
Ensure pump is in Auto mode			
Ensure the cut-in setting for pressure switch is kept as 4 bar as per design requirement			

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

6.6 Pump Startup Test Record

Description	Units	Expected	Actual
Volumetric Flow Rate	L/s		
Incoming Voltage	L-N (V)		
Control Voltage	(V)		
Battery charging current during float charging	(A)		
Battery charging voltage during float charging	(V)		
Battery charging current during boost charging	(A)		
Battery charging voltage during boost charging	(V)		
Engine starting current	(A)		
Pump Suction pressure	(m)		
Pump Discharge pressure	(m)		
Pump Operating Head	(m)		
Pump Shut Off Head	(m)		
Fluid Type	H20		

6.7 Local Control Panel Check

Description	Pass	Fail	N/A
Mains On (MO)			
Pump On Demand (POD)			
System On Auto (SOA)			
System On Manual (SOM)			
Engine Running (ER)			
Engine Fails To Start (EFTS)			
Low Lube Oil Pressure (LLOP)			
High Engine Water Temperature (HEWT)			
Engine Over Speed (EOS)			
Fuel Tank Level Low (FTLL)			
Mains Fail (MF)			
Ensure the pump starts manually when selector switch is in Auto mode			
Ensure the pump starts manually when selector switch is in manual mode			

6.8 Pump Functional Test

Description	Results		
	Pass	Fail	N/A
Verify Emergency Stop Functional Test			
Verify Thermal Overload Functional Test			
Ensure the pump kicks-in once the pressure in system is reduced to 4 bar			
Ensure there is no cut-off setpoint for diesel engine pump & the pump needs to be switched off manually once started			

VII. CONCLUSION

This paper is giving us the correct and simple testing procedure during commissioning. The goal of testing is to confirm the ability of major electro-mechanical equipment to continue functioning properly and reduce the chance of failure. By this, we ensure the quality of equipment.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 7, Issue 10, October 2020

DOI 10.17148/IARJSET.2020.71007

REFERENCES

[1]. Robert Guzman, Consultant, Airport Systems
[2]. Cx Procedure, i.d.a International
[3]. TIER 4 Nxtra Data Centre
[4]. Rajiv Gandhi International Airport

BIOGRAPHY

A graduate engineer with 13 years' experience in L&T in the field of Engineering Design & Research (EDRC) of Steel Plant Packages, Inspection (Factory Acceptance Test) of major & critical equipment, MEP Quality of TIER 4 Data Centre & Commercial Building Projects and presently taking care of testing & commissioning of MEP for Hyderabad International Airport Project. A Corporate Member of IEI (Institution of Engineers, India) and awarded as "Chartered Engineer" title