8.3 HP HEATER PERFORMANCE

8.3.1 Introduction

The performance of feed water heaters can be analyzed by monitoring the terminal temperature difference (TTD), drain cooler approach temperature (DCA), the pressure drop on the feed water side and the temperature rise across the heater. To monitor these it is desirable to carry out a simplified routine performance test on feed water heaters at a specified frequency. This will help in identifying the level of deviations and trending of performance.

8.3.2 Objective

The objectives of the routine on line high pressure feed water heater test are:

i. *Prior to an outage*, provide information to determine whether corrective action is required to maintain optimum feed water heater performance and provide guidance in determining materials, tools and equipment, workers, cost estimates, and scheduling.
ii. *Following an outage*, provide information to allow evaluation of the effect of work on the feed water heater.
iii. *During normal operation*, provide information to allow identification of abnormal changes in heater performance and provide information to assist in identifying the source of the change.
iv. *During normal operation*, provide information to assist in optimizing the operation of the heater.
v. *During normal operation*, provide information to allow accounting for the contribution of heater performance deficiencies on unit heat rate and capacity.

8.3.3 Test Procedure

8.3.3.1 Instrumentation

The parameters required to be monitored to conduct the HPH performance test consist of temperature, pressure/differential pressure instruments.

Measurement	*Temperature*	*Pressure*	*Remarks*
FW Inlet to Heater	1	1	
FW Outlet to Heater	1	1	
Extr. Steam at Heater End	1	1	
Drain Temperature	1		
FW Pressure Inlet& Outlet	-	1	
Shell Pressure	-	1	

*Preferably individual heater or differential pressure across the heater train

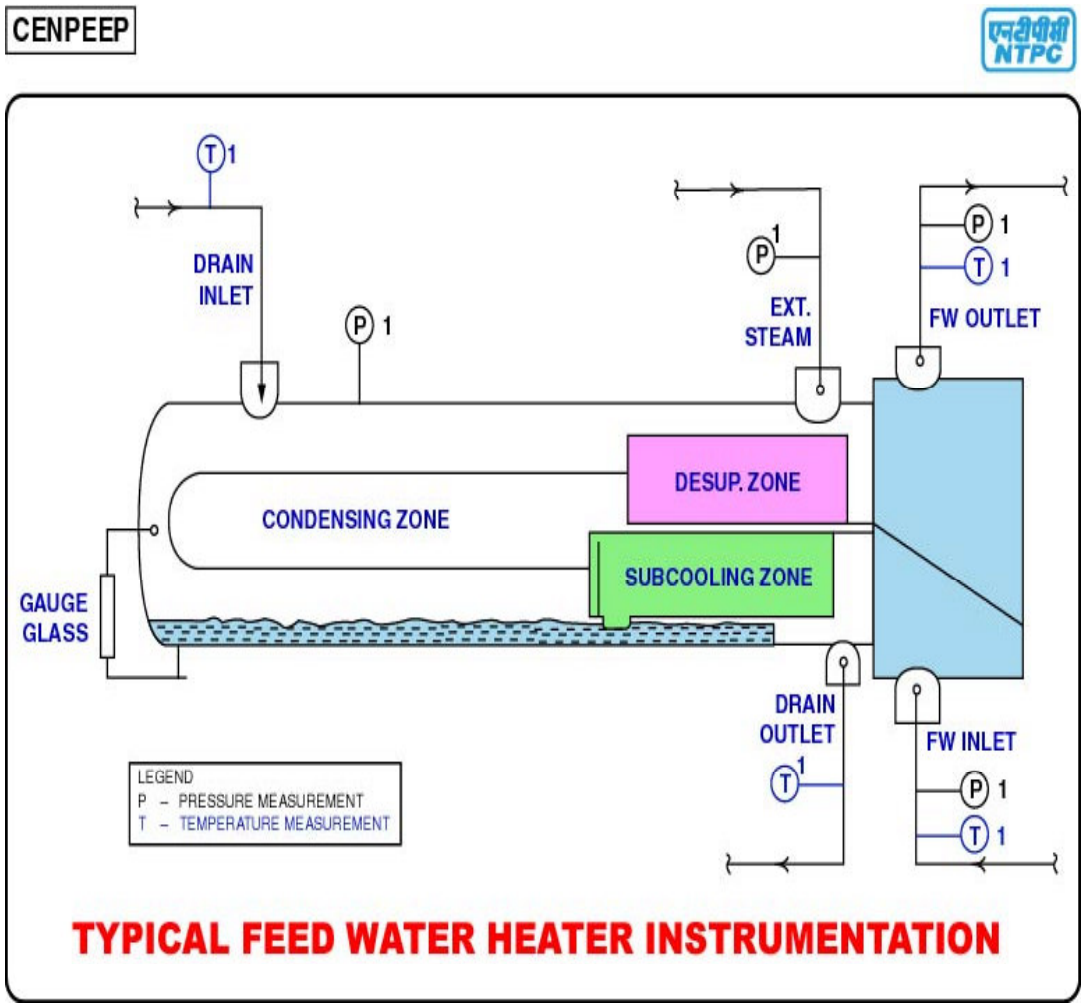

Fig-8.3.1

8.3.3.2 Data Collection

The performance test data from instruments will be recorded using sample format as given in Format - 8.3.1.

8.3.3.3 Test Setup

i. Unit should be in operation at normal full feed water flow and steady state condition.

ii. Ensure the heater drains are cascading as per the specified cycle conditions.

iii. Ensure venting of steam side and waterside to remove non-condensable gases.

iv. Operation of the feed water heater shall be brought to the steady state condition prior to initiating the test run. It shall be kept at this condition throughout the test run.

v. First test run is conducted at heater water level at normal design value. Subsequently, other test runs are conducted by varying the heater levels above and below the normal level.

8.3.3.4 Duration of Test Run and Frequency of Readings

i. Form a data group in the DAS for Data collection during the test (see format 8.3.2)

ii. Each test must be conducted for about 30 min for the purposes of data collection.

i. The frequency of data collection in DAS should be 1 min or minimum possible to achieve, depending upon the data collection rate of DAS.

8.3.3.5 Calculation and Analysis

8.3.3.5.1 Terminal Temperature (TTD)

$TTD = t_{sat} - t_{fw\ out}$

Where,
t_{sat} = saturation temperature corresponding to the heater shell pressure, °C.
$t_{fw\ out}$ = temperature of feed water leaving the heater, ° C.

8.3.3.5.2 Drain Cooler Approach Temperature (DCA)

$DCA = t_{drains} - t_{fw\ in}$

Where:
t_{drains} = temperature of the drains leaving the heater, ° C
$t_{fw\ in}$ = temperature of feed water entering the heater, ° C

8.3.3.5.3 Temperature Rise (TR)

$$TR = t_{fw\ out} - t_{fw\ in}$$

8.3.3.5.4 Extraction Steam Flow

$$(Q_e) = \frac{Q_f (h_{fw\ out} - h_{fw\ in}) + Q_{drain\ in} (h_{drains\ out} - h_{drains\ in})}{(h_{ext} - h_{drains\ out})}$$

Where:

Q_f	= Feed Flow
$h_{fw\ out}$	= Feed Water Enthalpy at HPH Out.
$h_{fw\ in}$	= Feed Water Enthalpy at HPH in
Q_e	= Extraction Steam Flow
h_{ext}	= Enthalpy of Extraction Steam
$h_{drains\ out}$	= Enthalpy of Drain Out
$h_{drains\ in}$	= Enthalpy of Drain In
$Q_{drain\ in}$	= Drain Inlet flow

Sample test report format is given in Format-8.3.2

8.3.4 Reference

Based on ASME performance test code PTC 12.1, 1978 on Closed Feed Water Heaters and HEI standards for Closed Feed Water Heaters.

8.3.5 Sample Computation : HP Heater Performance

1	Load	Mw	500.0
2	Fw Inlet Temp	^{0} C	194.3
3	Fw Outlet Temp	^{0} C	251.1
4	Extraction Steam Press	kg/cm^2(abs)	42.5
5	Extraction Steam Temp	^{0} C	340.8
6	Drain Out Temp	^{0} C	202.8
7	Fw Flow	t/hr	751.4
8	Drain In Temperature	^{0} C	0
9	Drain inlet flow	t/hr	0
10	Sat. Temp. Corresp. To Extraction Press.	^{0} C	252.8
11	Enthalpy Fw Out	kcal/kg	259.8
12	Enthalpy Fw In	kcal/kg	196.8
13	Enthalpy Of Extraction Steam	kcal/kg	729.4
14	Enthalpy Of Drain Out	kcal/kg	205.9

- **Terminal Temperature (TTD)**

  TTD $= t_{sat} - t_{fw\ out}$

  $= 252.8 - 251.1 = 1.7\ ^{o}$ C.

- **Drain Cooler Apporach Temperature (DCA)**

  DCA $= t_{drains} - t_{fw\ in}$

  $= 202.8 - 194.3 = 8.5\ ^{o}$ C.

- **Temperature Rise (TR)**

  TR $= t_{fw\ out} - t_{fw\ in}$

  $= 251.1 - 194.3 = 56.8\ ^{o}$ C.

- **Extraction Steam Flow**

$$(Q_e) = \frac{Q_f (h_{fw\ out} - h_{fw\ in}) + Q_{drain\ in} (h_{drains\ out} - h_{drains\ in})}{(h_{ext} - h_{drains\ out})}$$

Where:

Q_f	= Feed Flow
$h_{fw\ out}$	= Feed Water Enthalpy at HPH Out.
$h_{fw\ in}$	= Feed Water Enthalpy at HPH in
Q_e	= Extraction Steam Flow
h_{ext}	= Enthalpy of Extraction Steam
$h_{drains\ out}$	= Enthalpy of Drain Out
$h_{drains\ in}$	= Enthalpy of Drain In
$Q_{drain\ in}$	= Drain Inlet flow

$$Q_e = \frac{751.2 * (259.7 - 196.8) + 0}{(729.4 - 205.95)} = 90.2 \text{ t/hr}$$

HP Heater Test Data

Stat**ion: ..... Unit: ..... Test Date: .....**

S.N	MEASUREMENT	Unit	Test
1	Unit Load	MW	
2	Feed Water Flow	t/hr	
3	HPH-5 Extraction Temp	^{0} C	
4	HPH-5 Extraction Press	kg/cm^2(abs)	
5	FW Entering HPH-5 Temp	^{0} C	
6	FW Entering HPH-5 Press	kg/cm^2(abs)	
7	HPH-5 Drain Outlet Temp	^{0} C	
8	Drain Inlet Temp to HPH-5	^{0} C	
9	HPH-6 Extraction Temp	^{0} C	
10	HPH-6 Extraction Press	kg/cm^2(abs)	
11	FW Entering HPH-6 Temp	^{0} C	
12	FW Entering HPH-6 Press	kg/cm^2(abs)	
13	HPH-6 Drain Outlet Temp	^{0} C	
14	Drain Inlet Temp to HPH-6 (If applicable)	^{0} C	
15	HPH-7 Ext. Temp (If applicable)	^{0} C	
16	HPH-7 Ext. Press (If applicable)	kg/cm^2(abs)	
17	FW Entering HPH-7 Temp (If applicable)	^{0} C	
18	FW Entering HPH-7 Press (If applicable)	kg/cm^2(abs)	
19	HPH-7 Drain Outlet Temp (If applicable)	^{0} C	
20	HPH-5 Level	mm	
21	HPH-6 Level	mm	
22	HPH-7 Level	mm	

Format-8.3.1

HP Heater Performance Report

Station **Report Date**
Unit **Date of test**

S.N	PARAMETER	UNIT	HPH-5		HPH-6		HPH-7	
			Design	Test	Design	Test	Design	Test
1	LOAD	MW						
2	FW FLOW	t/hr						
3	HPH Ext. Temp (Htr End)	^{0} C						
4	HPH Ext. Press (Htr End)	kg/cm^2(abs)						
5	FW Inlet Temperature	^{0} C						
6	FW outlet Temperature	^{0} C						
7	HPH Drain Outlet Temp.	^{0} C						
8	Drain Inlet Temp. to HPH	^{0} C						
RESULTS								
1	TTD	^{0} C						
2	DCA	^{0} C						
3	Extraction Flow to HPH	t/hr						
4	FW Temperature Rise	^{0} C						

Test Conditions:

Remarks :

Format-8.3.2