<table>
<tr><td colspan="3">INTERPLANT STANDARD - STEEL INDUSTRY</td></tr>
<tr><td rowspan="2">IPSS</td><td>SPECIFICATION FOR INFRA-RED PYROMETERS</td><td>IPSS: 2-07-017-13
(First Revision)</td></tr>
<tr><td>NO CORRESPONDING INDIAN STANDARD EXIST</td><td>Formerly-:
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0. FOREWORD

0.1 This Interplant Standard was prepared by the Standards Committee on Computerization & Automation, IPSS 2:7, with the active participation of the representatives of all the steel plants, other concerned organizations and established manufacturers in the field. Originally, the standard was published in 1993. Based on recent developments, it is revised and adopted in February, 2013.

0.2 Interplant standards on design parameters primarily aim at achieving rationalization and unification of parts and assemblies of process and auxiliary equipment used in steel plants and these are intended to provide guidance to the steel plant engineers, consultants and manufacturers in their design activities.

0.3 **Objective** – Objective of this standard is to give specification of Infra-Red Pyrometers to help selection of the same for the purpose of measurement of temperature at various locations in the steel plant. A description of an Infra-Red Pyrometer is given in the Appendix-I.

1. SCOPE

1.1 This Interplant standard covers the requirements of details of the Infra-Red Pyrometer to enable proper selection for various users.

2. DEFINITIONS

2.1 Emissivity – The ratio of emitted radiations to that which would be emitted by a black body at the same temperature.

Spectral emissivity is defined at each wave-length and total emissivity is averaged over all wave-length.

2.2 Reflectivity – The proportion of incident radiations which is reflected at a surface.

2.3 **Target** – The intersection of any plane with the cones of field of view of an infra-red pyrometer is called the target of the pyrometer on that plane. If field of view is circular, then target is also circular on a plane perpendicular to them. If the plane makes an angle with axis, then target is an ellipse with an axis on inclined plane and d * sec (axis angle) is major axis of eclipse, whereas d is the target diameter.

2.4 **Target Size** – Target size is a property of pyrometers and is given as a factor of distance of the object from the pyrometer. Thus target size mentioned as D/200 indicate that target diameter will be 1/200 of the distance of the object from the pyrometer.

3. GENERAL

3.1 Categories

a) Broad Wave Band – These utilize the energy emitted in wise wave band.

b) Selected Wave Band – These utilize emitted energy in selected part of spectrum to take advantage of high absorption or emissions in that wave band.

c) Short Wave Length – These are members of selected wave band pyrometer but are categorized separately because of many special virtues particularly with metal surfaces. They work on the basis of energy emitted at particular wave length.

d) Ratio Pyrometer (two colours) – These work on the basis of ratio of the energies emitted in selected two wave length.

3.2 Time Functions – These are used to modify the output to avoid its variation in an unacceptable manner.

4. SELECTION OF PYROMETER

4.1 The infra-red pyrometer will be chosen on the basis of the following:

a) Range & applications

b) Accuracy

c) Place of installation

d) Ambient

e) Target size and distance

f) Response time

g) Output signal required

h) Time functions

i) Extension of Optics by using Fiber Optics Cables as required.

Range and applications are to be decided by the type of detectors. The Table-1 gives ranges that are recommended to have proper accuracy and speed of response.

In order to get best result shortest wave-length pyrometer that gives the necessary lowest measuring temperature will always be chosen.

5. ACCURACY

5.1 Accuracy requirement will depend upon the process. Recommended accuracy for all measurement is 1% of the scale range or better in the working range.

6. PLACE OF INSTALLATION

6.1 Arrangements of sealing the pyrometer are essential and should be provided suitably depending upon the process pyrometer at the place of installation. The emmissivity correction should be provided depending upon whether the target is open or closed.

7. AMBIENT

7.1 Suitable cooling (water or air) arrangement will be provided for cooling the pyrometer. Air purge will also be provided for keeping the lens clean. Air cooling is recommended upon ambient temperature of 80 deg C. Beyond this, water cooling should be provided.

7.2 Target sizes pyrometer with distance factor of 20, 50, 100 and 200 are recommended to cover all the applications. Provision of using short lens will be made if surface is smaller than the standard larger size of the pyrometer.

8. RESPONSE TIME

8.1 Recommended response time should be within 0.01 to 0.1 second (63% indication).

9. OUTPUT SIGNAL

9.1 At least two independent computer compatible outputs e.g. 4-20 mA dc or 0-100 mV dc or FIPS (field interface protocols) will be provided in all the pyrometers.

10. TIME FUNCTIONS

10.1 All pyrometers will be provided with following time functions through interchangeable cards having no need of adjustment:

i) Peak
ii) Average
iii) Sample & hold

11. CALIBRATION

11.1 Each infra-red pyrometer will be tested and calibrated against a thermocouple or standard radiation pyrometer using a black body furnace. Suitable thermocouple may be used upto 1400oC and radiation pyrometer from 1000oC onwards. A traceable National Standard calibration certificate will accompany the pyrometer.

12. ELECTRONICS

12.1 Each pyrometer shall have a dedicated microprocessor with facility for range change, calibration, self diagnosis etc. Digital Display shall be provided showing the following parameters.

1. Temperature
2. Emissivity
3. All Configurable Parameters.
4. Adjustment facility for all above parameters

APPENDIX – 1
(Clause 0.3)

The basic structure of infra-red pyrometer is shown in the Fig.1. The main variables are as follows:

1) **Detector** – Different detectors can be used to produce a range of wave length sensitivities and speed of response.

2) **Lens** – The focal length can be varied to accommodate different target size and target to distance ratio. In addition, the lens material (or an additional optical filter) can be used to control the wave length range.

3) **Field stop and Lens stop** – The size and lens stop can be varied to meet the target size requirement of the application. The basic pyrometer shown in Fig.1 would give a low level non-linear output. To overcome this difficulty and to increase the capability, an electronic amplified is included in the pyrometer head. This simplifies the subsequent electronic signal processing besides reducing the susceptibility of the instruments to electrical interference from heavy duty electrical equipment. Modern pyrometers with electronic signal processing provide high level linear output signals that are readily compatible with computer and control systems which can be further processed to minimize such effects as cold patches of scale on steel or the presence of smoke or steam in the atmosphere. Equally important in the pyrometer design and selection are the design of its accessories and the installation and maintenance of the equipment particularly when the thermometer has to operate in the hop and dirty environment of a steel plant.

4) **Categories** – There are various possible combinations based on the pyrometer design in terms of detector, optical system and electronic system but most of them can be placed into four basic categories:

   a) Broad wave band
   b) Selected wave band
   c) Short wave length
   d) Ratio two colour

   Their selection depends upon various factor. But in general, broad wave band types are on their way-out. Generally short wave length pyrometers are used. In some typical cases, ratio (two colour) pyrometers are preferred.

   Besides above general categories, there may be many special categories to suit special purposes like measurement of surface temperature and round the corner temperature measurement using fiber optics between fields.

5) **Time Functions** – In many applications it is necessary or desirable to modify the output because it would otherwise vary in an unacceptable manner. The common time function are peak picker, average and sample and hold. These are achieved through cards which are directly interchangeable on site with no need of adjustment.

a) Peak – It is used when cold object frequently come in view of the pyrometer or hot objects are moving through the field of view of pyrometer. With this time function the output resistance when hot object comes in view and decays slowly when it is absent short-term interruptions are ignored. The decay rate is adjustable so that the real temperature trend can be followed.

b) Average – It is used to average the rapidly varying output. It has an adjustable response time.

c) Sample & Hold – It is used when hot object is in view of the pyrometer for only a short time during a process cycle. This feature enables pyrometer to follow the temperature when external command is given but holds the last value when it is removed. The value will be held until the external command is given again.

6) **Selections of pyrometer –** The pyrometer are selected on the basis of various factors. Some typical factors are tabulated in the summary of factors affecting choice of pyrometer.

TABLE-1 - RECOMMENDED RANGES AND DETECTORS FOR SHORT WAVE LENGTH PYROMETER

(Clause 4.1)

Type of Detection	Measuring Wave Length in micron	Scale Range (deg C)	Recommended Scale (deg C)
Pb Se	4.0	100 - 500	100 - 500
Pb S	2.0	150 - 1000	150 - 450 200 - 600 300 - 800 400 - 900 500 - 1000
Si	0.9	600 - 3500	600 - 1100 700 - 1200 800-1400 900 - 1700 1000 - 2000 1100 - 2500 1500 - 3500
Thermistor or Bolometer	2 - 22	-50 - 600	-50 – 100 0 – 200 50 – 300 100 – 400 150 – 500 200 - 600

TABLE-2 - RECOMMENDED RANGES AND DETECTORS FOR 2 COLOURS OR RATIO PYROMETER

Type of Detection	Measuring Wave Length in micron	Recommended Scale (deg C)
Pb S	2.15 / 2.40	150 - 450 200 - 600
	2.05 / 2.35	300 - 800 400 – 900
	1.75 / 2.35	500 – 1100 600 – 1200
Si	0.85 / 1.0	700 - 1500 800 -1000
Photo multiplier tube	0.50 / 0.58	1000 – 2000 1500 – 3500

TABLE-3 – SUMMARY OF FACTORS AFFECTING CHOICE OF PYROMETERS

Sl.No.	Factor	Technical Problem	Effect on Choice of Pyrometer
1.	Varying Target Conditions		
	a) Varying degree of oxidation	Change of emissivity, wave length	Nearly always favours short wave-length pyrometer
	b) Varying always	Change of emissivity	Must be individually assessed
	c) Cold patches e.g. scales	Potential for falsely low reading	So either ratio pyrometer. Small target short wave length pyrometer with peak picker. Later is better if `cold' patches are less than 200-300 deg C colder than true temperature.
	d) Convolations of liquid metal stream	Causes change in effective emissivity	Ratio pyrometer is better than single waveband but usually neither gives adequate accuracy.
	e) Varying target size and 100 position	Target can move out of field of view of pyrometer	Use either ratio pyrometer or short wave length pyrometer with peak picker.
	f) Polarization	Degree of polarization varies with angle between sighting direction and normal to surface	Must use a pyrometer which is not affected by polarization of incident energy. Avoid pyrometer incorporating angled mirror or semi-mirror
2.	Absorption in Sight Path		
	a) Atmospheric water vapours or CO_2	Loss of energy in specific wave bands	"Short wave length" pyrometer below 1.8 m are ideal, ratio pyrometer will give large errors if either wave band effected.
	b) Furnace smoke	Scattering losses very wave length dependent	"Short wave length" preferred. Ratio pyrometer measure – colour temperature and can given very low readings e.g. sun through fog.
	c) Dust / Large particles	Above a certain size, loss is not very wave length dependent	Use ratio pyrometer
	d) Steam (water droplets)	Above a certain size, loss is not very wave length dependent	Use ratio pyrometer

	e) Water layer	Absorption loss except at very short wave length	Use short wave length pyrometer
3.	**Reflection of daylight or tungsten lamps**	Reflection gives a falsely high reading particularly bright metals at low temperature	Must be eliminated by shielding

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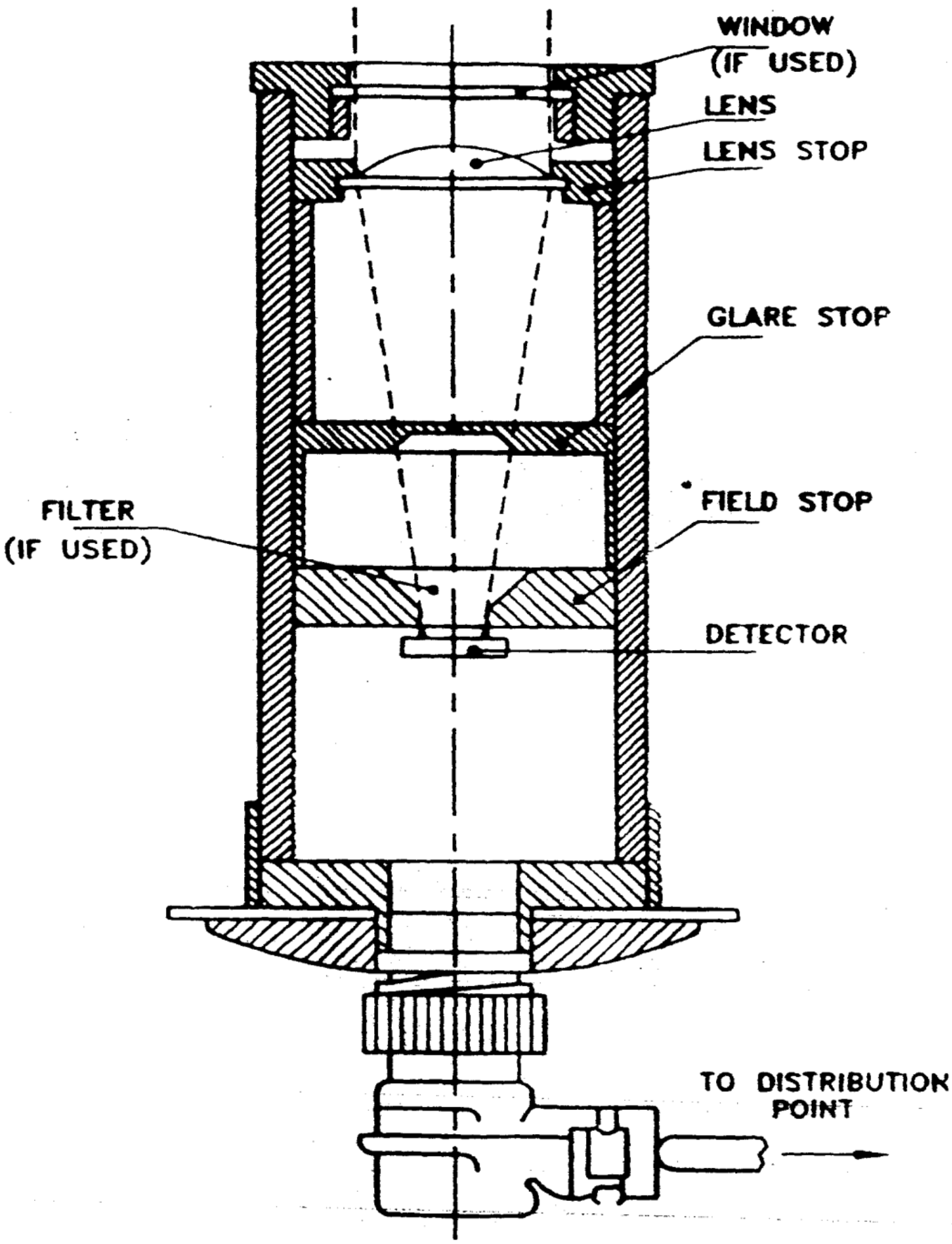

FIG.1 SCHEMATIC REPRESENTATION OF AN INFRA-RED PYROMETER