भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

Doc. No. : PRTD/AR/**PF:03**	Issue No. : 2	Issue Date 30 Sept. 2020	**Report of Action Research**

1.	**Action Research Project No.** *(as assigned by PRTD)*	AR/0138
2.	**Title of the Action Research Project**	Standards in Concentrated Solar Thermal Technologies
3.	**Name & Designation of Officer**	JS Kavin Keerthy Vinayagam, Scientist - C
4.	**Employee No.**	068012
5.	**Deptt./BO/RO & Place of Posting**	CMD-III, HQ
6.	**Date of Approval of the Project**	22 December 2020
7.	**Objective of the Project**	Inspite of availability of many manufacturers in CST field, there are no existing BIS licensees. The objective of this research project is to identify reason and try to suggest ways for improvement.
8.	**Report of Action Research Activities**	Report enclosed
9.	**Conclusion & Recommendations**	On studying and comparing Indian Standards with International standards and interacting with the CST it was observed that the lack of interest in getting certified arises due to very low market demand in the country.
10.	**Any other relevantinformation**	No financial claim has been availed. Inputs from members of industry as well as technical committee has been utilised.

31/3/2021
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CONTENTS

Standards in Concentrated Solar Thermal Technologies

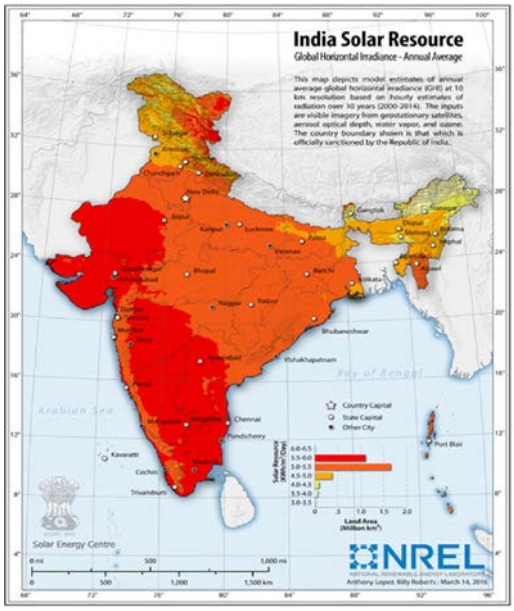
Bureau of Indian Standards has published IS 16648 series of Indian Standards for Concentrated Solar Thermal technologies in the year 2017-18. Although there are about 20 Indian manufacturers empanelled by MNRE for installation of solar CST based systems as of 2014, there are no licensees in the country for the above said standards till date. The action research project aims to study the Indian Standards available for solar concentrated technologies and ascertain the reason for the lack of interest on BIS product certification among the Indian manufacturers.

Methodology

The method employed in this action research involves two approaches. In the first section of the project the specification of the Indian Standards is studied and the same are compared to similar standards available and adopted internationally. This is done in order to ensure that the standards are in alignment with the best industrial practices and market requirements. In the second section of the project inputs from industries are collected and analysed to identify the reason for the lack for need of certification in Indian market.

Solar Concentrated Technologies

All the renewable energy sources available for harnessing power like wind energy, tidal power, etc, can be traced back to Solar energy. Amongst them Concentrated Solar Thermal (CST) Technologies and Solar Photo Voltaic (PV) technologies are the ones harnessing power directly from the solar radiation. India is located in the equatorial sun belt and receives plenty of solar radiation. The daily average global solar radiation is 5-7 kWh/m^2 and about 3000 hours of sunshine is available per annum.



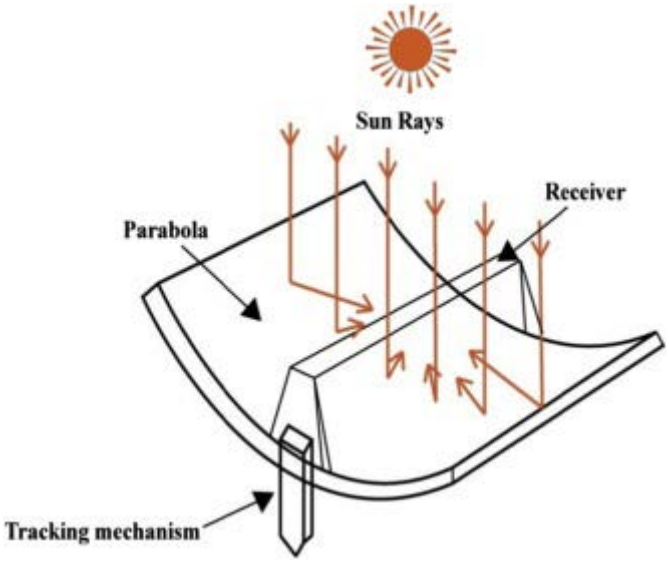
Unlike PV technology which is used solely for electricity generation, Concentrated Solar Thermal technologies have a wide range of applications such as Process Heating, Desalination, Steam generation, Furnace operation, Power generation etc. The efficiency of the system as defined by second law of thermodynamics depends on the temperature difference of the source and sink, higher the difference more efficient the system. Thus, CST technology relies on generating high temperatures. In order to cater the wide range of applications many types of CST systems have been designed some of the common systems are as follows:

Solar Flat Plate collector:

This is one of the basic and most widely used CST system. It is a non-imaging concentrator system. The system employs evacuated glass tubes to trap and augment solar energy as heat which in turn rises the temperature of a fluid. Typical applications are found in hot water supply system and temperature achieved about 80^{o}C.

Parabolic Trough Concentrator:

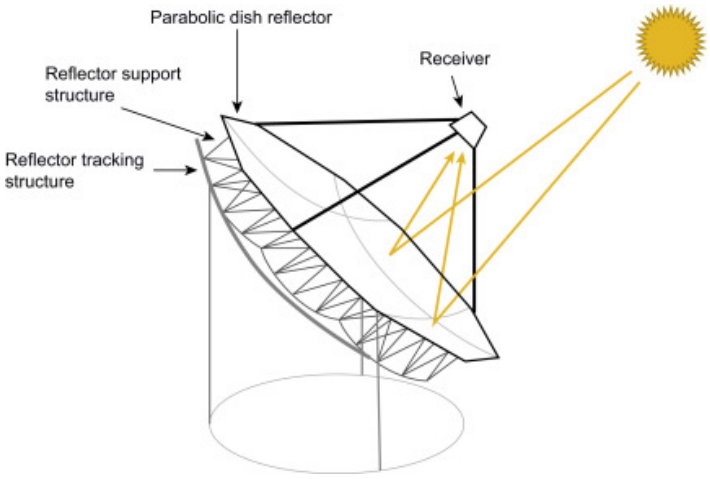
This system involves reflection of incident solar energy onto a line to concentrate the radiation. The reflector in this system has a parabolic cross section area. The receiver is situated at the line coinciding with the focal point of the parabola.



This is one of the versatile systems that can be used for desalination, steam and power generation. The fluids inside the system reaches about 200^{o}C.

Paraboloid Dish Concentrator:

This system is similar to the PTC technology except instead of a line focus, this system uses a parabloid surface as a reflector to concentrate the incident radiation onto a point focus. The receiver is situsted at the focus of the paraboloid.



This system can generate high temperatures of about 350°C and finds application in power generation through operating a Stirling engine and steam generation.

Other CST technologies like central receiver system employs hundreds of mirrors arranged so as to concentrate incident radiation on to a central tower. The temperature achieved in this system are high in the order of 500 to 750°C. These temperatures may be utilised in furnaces to melt metals and in high demand power generation systems with efficiencies comparable to that of conventional energy generation systems.

Analysis of Global standards on CST

From the literature survey of available standards on CST, it was observed that the indigenous standards developed by the Bureau of Indian Standards are one of a kind. No such comprehensive standards for a CST system are available internationally. However, standards on components of a CST technology such as collector, evacuated tubes, tracking system, etc. are available. Further these standards serve more of a standard on testing procedures rather than a product standard for the purpose of certification.

One such component where International and reputed national standards are available is solar collectors. ISO 9806 – Solar thermal collectors – Test method. The standard specifies test methods for assessing the durability, reliability, safety and thermal performance of fluid heating solar collectors. This standard applies to a variety of solar collectors that are used for heating fluids from flat plate to parabolic trough collectors. The standard covers the method of test for air leakage rate determination, rupture and collapse test, stagnation temperature determination, exposure, external and internal thermal shock

resistance, rain penetration, thermal performance, pressure drop, freeze resistance, impact resistance, mechanical load, internal fluid pressure tests.

BS EN 12975-1- Thermal solar systems and components. Solar collectors- General requirements. It is a European Standard which specifies requirements on durability (including mechanical strength), reliability and safety for liquid heating solar collectors. This standard is similar to that of ISO 9806, except the fact that this standard does not apply to air heating systems. Also, some tests like rupture and collapse, impact resistance tests are not available in this standard.

CAN/CSA-F378-87 - Solar Collectors. This standard is from Standards Council of Canada (SCC). This Standard specifies a set of technical requirements and test methods for solar collectors and covers component materials, materials performance, operating performance, and marking requirements. This is applicable to air heating systems also but has limited coverage compared to ISO 9806. The standards cover major tests for the solar collectors but misses out on stagnation temperature determination, impact tests and some other tests.

Certification schemes like Solar keymark of the European Union, Solar Rating and Certification Corporation (SRCC) of US and other certification bodies certify the components based on EN 12975 and ISO 9806. By large the products certified are solar flat plate collectors/water heaters employing evacuated tube collectors.

Brief Overview of the Indian Standards

IS 16648 (Part 1) - Concentrated Solar Thermal Specification - Paraboloid Dish Concentrator

Scope - This standard specifies the requirements of paraboloid dish concentrator for process heating and steam generation for temperature range of 60°C to 350°C.

The Standards specifies requirements for the following:

1. Material, Optical characteristics, weathering and corrosion resistance of reflectors.
2. Material, Optical characteristics, coating, weathering and corrosion resistance of receiver assembly.
3. Material and design of support structures, foundation.
4. Mechanical, Electrical components of tracking system.
5. Protection against weathering of Electronic components and panels.
6. Safety and performance characteristics such as response to no flow conditions, Optical efficiency, thermal efficiency, time constant, etc.

The standard in addition to the above specifications also specifies general guidelines on design of the concentrator, dimensional accuracy and tolerances in dimensioning, conditions of quasi steady state, requirement of instruction manual, marking, formats of test reports and performance graph.

The standard refers to IS 16648 (Part 5) for test procedures, pre conditioning and calculations of performance characteristics.

IS 16648 (Part 2) - Concentrated Solar Thermal Specification - Scheffler Concentrator

Scope - This standard specifies the requirements of scheffler dish and various components for process heating and steam generation for temperature range of 100°C to 175°C.

The Standards specifies requirements for the following:

1. Material, Optical characteristics, weathering and corrosion resistance of reflectors.
2. Material, Optical characteristics, coating, weathering and corrosion resistance of receiver and collector assembly.
3. Material and design of support structures, foundation.
4. Mechanical, Electrical components of tracking system.
5. Protection against weathering of Electronic components and panels.
6. Safety and performance characteristics such as response to no flow conditions, Optical efficiency, thermal efficiency, time constant, etc.

The standard in addition to the above specifications also specifies general guidelines on design of the concentrator, dimensional accuracy and tolerances in dimensioning, conditions of quasi steady state, requirement of instruction manual, marking, formats of test reports and performance graph.

The standard refers to IS 16648 (Part 5) for test procedures, pre conditioning and calculations of performance characteristics.

IS 16648 (Part 3) - Concentrated Solar Thermal Specification – Parabolic Trough Concentrator

Scope - This standard specifies the requirements of solar parabolic trough collector (PTC) for process heating and steam generation for temperature range of 60°C to 250°C (Pressure ≤ 40 bar).

The Standards specifies requirements for the following:

1. Material, Optical characteristics, weathering and corrosion resistance of reflectors.
2. Material, Optical characteristics, coating, weathering and corrosion resistance of receiver, absorber tube and collector assembly.
3. Material and design of support structures, foundation.
4. Mechanical, Electrical components of tracking system.
5. Protection against weathering of Electronic components and panels.
6. Safety and performance characteristics such as response to no flow conditions, Optical efficiency, thermal efficiency, time constant, incident angle modifier, etc.

The standard in addition to the above specifications also specifies general guidelines on design of the concentrator, dimensional accuracy and tolerances in dimensioning, conditions of quasi steady state, requirement of instruction manual, marking, formats of test reports and performance graph.

The standard refers to IS 16648 (Part 5) for test procedures, pre conditioning and calculations of performance characteristics.

IS 16648 (Part 4) - Concentrated Solar Thermal Specification – Non-Imaging Concentrator

Scope - This standard specifies the requirements of non-imaging concentrator (NIC) for process heating and steam generation for temperature range of 60°C to 120°C.

The Standards specifies requirements for the following:

1. Material, Optical characteristics, weathering and corrosion resistance of reflector.
2. Material, Optical characteristics, coating, vacuum durability, mechanical integrity, fin design, weathering and corrosion resistance of receiver assembly (Evacuated Tube).
3. Material and design of support structures, foundation.
4. Mechanical, Electrical components of tracking system.
5. Protection against weathering of Electronic components and panels.
6. Safety and performance characteristics such as response to no flow conditions, Optical efficiency, thermal efficiency, time constant, incident angle modifier, etc.

The standard in addition to the above specifications also specifies general guidelines on design of the concentrator, System arrangement, dimensional accuracy and tolerances in dimensioning, conditions of quasi steady state, requirement of instruction manual, marking, formats of test reports and performance graph.

The standard refers to IS 16648 (Part 5) for test procedures, pre conditioning and calculations of performance characteristics.

The structure of the IS 16648 series is such that it specifies the requirement of the material used in the system, specifies the performance requirements and gives additional guidelines on reporting the data of the testing. There is a dedicated standard for specifying vocabulary, specification of measuring equipment and testing procedures. The series uses a quasi-steady modelling for testing the performance of the system which is in par with the practises followed internationally. A key point to be noted in this regard is that the Indian Standards also provides the specification for foundation and civil construction required for structural soundness of the system. As seen above a direct comparison of the Indian Standards with the internationally available standards would not yield any benefit since the aim the standards are different. Standards like ISO 9806 and EN 12975 although specifies requirements for the solar thermal collectors they focus more on collectors rather than the whole system and serve more on establishing the testing procedure. From interactions with the stakeholder and from the composition of

the committee involved in the development of these standards it is observed that the standard has been developed by the active participation of Industrial, academic and regulatory bodies and as such does not pose any hurdle to certification.

Solar Thermal manufacturing sector in India

As per data from MNRE as of 25th November 2014 there are 20 manufacturers capable of installing CST based systems such as Single and double axis tracked scheffler dishes, Single axis tracked parabolic troughs, Double axis tracked paraboloid dishes, double axis tracked Fresnel based dishes. ETC based non imaging concentrating systems.

From the interactions with representatives of these industries it was observed that most of the components like glazing, tracking systems are imported and assembled either in the factory or in the field directly. Current Indian market scenario leans more towards PV technology when it comes to solar based power generation systems.

Solar PV as a technology is much more mature that CST technology. Due to intensive research and development more affordable efficient PV panels are mass produced and distributed. The allied products with PV like circuits, power generating elements, storage systems like DC battery and convertors are already well established as stand alone products and easily available in the market. Such a well established eco system for Solar thermal systems are unavailable in India. Thermal storage systems, fluid handling systems, are relatively complicated systems and are not readily available, they have to be designed specifically for the need. Other parts like glazing and curved mirrors are not as readily available in the Indian market as their PV counterparts in spite of the availability of competent industries and involving relatively simple manufacturing process. Further the maturity of the technology and ready availability of components and accessories makes it accessible to lot of start-ups with low capital and greatly facilitates domestic usage, whereas solar thermal based technologies are not widely used for domestic purposes except for ETC based solar water heaters.

Concentrated solar thermal technologies requires sophisticated site data, design of the plant includes requirement of various data such as Direct Normal Irradiance (DNI), Global Horizontal Irradiance (GHI), wind speed, annual rain fall, etc which are not readily available. India has experience of only a couple of Concentrated Solar Power projects working Jawaharlal Nehru National Solar Mission (JNNSM) under the National Action Plan on Climate Change (NAPCC). The lack of encouragement for CST from the government is also cited as a reason for slow development on manufacturing of CST based products. Indian government is focussed and tirelessly working on increasing the share of renewable energy in meeting the country's energy demand. But most of the government schemes help improve PV based technologies rather than CST technologies. For example, the idea in phase 1 of JNNSM was to give equal emphasis to both solar photovoltaic (PV) as well as CSP technologies and

projects were allocated accordingly. However, the share of CSP was reduced to 30% in the second phase.

Conclusion

Growth of a certain renewable energy technology depends on cost per unit of energy generation, power dispatchability on demand and availability of ancillary services. The problem that this research project attempted to analyse i.e., the lack of certification in India for CST technological products arises due to lack of sufficient momentum in manufacturing concentrated solar technological products and its ancillary services. As there are no sufficient production going on in the country manufacturers are reluctant in involving compliance cost to their capital in an already slow-moving market. This lack of certification by a competent third party, coupled with less motivation from government for the technology, availability of affordable alternative technology and unavailability of long-term ground data on solar variables leads to reduced confidence among investors. Thus, the cause and the effect produce a vicious circle.

The IS 16648 series published by BIS on Concentrated Solar Thermal technologies are unique in its construction and is in par with the practices global CST society, catering to the need of the consumer and industries alike. Even though the series consists of vertical standards, they are developed in such a way that it does not hamper innovations in the technology with is very much needed since this technology is in its early stage of development. It covers the individual CST product in its entirety from raw materials to constructional and performance requirements. BIS may utilise the resources available in this regard for further development of standards that provides either specification or code of practice for other support systems of CST such as Thermal storage system, fluid handling system in CST, etc. which will come in handy when the situation in the manufacturing sector improves.

Nomenclature

CST – Concentrated Solar Technology

CSP - Concentrating Solar Power

JNNSM - Jawaharlal Nehru National Solar Mission

NAPCC - National Action Plan on Climate Change

PTC – Parabolic Trough Concentrator

GHI – Global Horizontal Irradiance

DNI – Direct Normal Irradiance

MNRE – Ministry of New and Renewable Energy

ETC – Evacuated Tube Collector

NIC – Non-Imaging Concentrator

SRCC - Solar Rating and Certification Corporation

Reference

1. Technical and economic potential of concentrating solar thermal power generation in India, Ishan Purohit, Pallav Purohit, Renewable and Sustainable Energy Reviews.
2. Harmonization of standards for parabolic trough collector testing in solar thermal power plants, Fabienne Sallaberry, Loreto Valenzuela, Luis G. Palacin, Javier Leon, Stephan Fischer, and Andreas Bohren.
3. Solar thermal power generation in India, techno-economic analysis, S. Beerbauma, G. Weinrebe, Renewable Energy 21 (2000) 153-174
4. Standards and Certification Schemes for Solar Thermal Collectors, Stores and Systems - An Overview about the latest Developments, Stephan Fischera, Harald Drücka, Energy Procedia 57 (2014) 2867 – 2871.
5. Guide to standard ISO 9806:2017 A Resource for Manufacturers, Testing Laboratories, Certification Bodies and Regulatory agencies, version 1.0.
6. IS 16648 (Part 1 to 5)
7. Inputs from Technical committee members and Industry.

DECLARATION OF ORIGINAL WORK

I, JS Kavin Keerthy Vinayagam, Scientist-C (CMD III), Employee No. 068012 hereby declare that the Action Research Project titled "Standards in Concentrated Solar Thermal Technologies" is the original research work done by me. I have not copied from any other Action Research Project or any other work of similar nature and topic done by any person/institution/body either published or yet to be published. Data and information from other sources, used if any, have been with prior permission, wherever required and is duly acknowledged appropriately in the project report submitted by me.

This declaration is made on the 31st day of 2021.

31/3/2021

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Scientist - C