



UNITED NATIONS  
INDUSTRIAL DEVELOPMENT ORGANIZATION



GOVERNMENT OF INDIA  
**MINISTRY OF NEW  
AND RENEWABLE ENERGY**



# Review of IBR Regulations for CST Systems

MNRE-GEF-UNIDO

*“Promoting business models for increasing penetration and scaling up of solar energy”*

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION



# Executive Summary

The Central Boiler Board (CBB) in India is responsible for establishing regulations for boiler materials, design, construction, as well as for registration and inspection. The Government of India Act, 1935 assigned the subject 'Boilers' to the concurrent field. Presently, the Indian Boiler Regulations (IBR) do not apply to hot water generation from concentrating solar thermal (CST), but steam applications still fall under the purview. If a CST system is generating steam and total system water holding capacity exceeds 25 liters and pressure is more than 2 bar (1kg/cm<sup>2</sup> gauge) absolute, then the steam generator is treated as a boiler as per Boiler Act 1923. In recent times, we have seen bigger players such as Thermax, easily been able to meet the stipulated criteria and get their boiler systems certified as per IBR compliances. However, when it comes to smaller manufacturers or new market entrants, many of them are facing issues in adopting the set of guidelines mandated under IBR. Hence, in order to analyze the situation effectively this dilemma has to be resolved- ***'Are the IBR regulations too stringent for adoption or there is negligence from manufacturers end?'***

From preliminary secondary research and stakeholder consultations, it is evident that there are certain key challenges faced by the industry in terms of complying with IBR requirements. With respect to IBR compliance, certain CST players have highlighted their experience, which involved lot of hassles, additional costing (owing to ensuring IBR compliance) and certain regional level challenges when it comes to approval for boiler design. However, for most cases the present IBR regulations (after series of amendments) cover the necessary guidelines and standards for all boiler related aspects covering manufacturing, erection and inspection. Hence, there is a definite gap on part of manufacturers in the awareness levels and knowledge expertise required to cater to IBR requirements.

Additionally, it has been realized that the IBR is flexible in its approach and allows for few relaxations when it comes to physical dimensions and mechanical properties of certain components. Several manufacturers are not aware

of this flexibility aspect and the possibility of approval on a case to case basis. However, it is a generally accepted fact that the relaxations should be designed, bearing in mind that safety of the system should not be compromised. Maximum compliance to IBR provides the necessary guarantee to safety, which the industry must follow.

**Strict compliance in particular sections:** Implying that the technical specifications of different component or sub-components (typically mechanical) are extremely stringent and need to be adopted in 'exact manner' without any allowance for tweaking

**Tedious procedures:** Implying that the approvals, clearances procedures, paper-work and other mandatory requirements are extremely cumbersome and difficult for manufacturers to adopt

**Lack of awareness:** Implying manufacturers/suppliers do not have the know-how about the exact guidelines and technical requirement to follow under IBR

However, as discussed some of these areas of intervention might have to be revisited to make overall framework more conducive for integrating CST steam boilers. There is a definite requirement of 'training and capacity building' with respect to the latest technical specifications, standards and performance criteria of key components, (dimensions, pipes, material, steam valves and fittings, welding, plumbing requirement, etc.) owing to complete lack of awareness.

In this regard, the following measures have been proposed to ensure that manufacturers can seamlessly deploy CST systems while complying with IBR.

**Simplification:** Making overall procedures for compliance leaner and more accommodative (flexibility needs to be introduced for key components)

**Exemptions:** Possible exemption that can be designed specific to CST steam boilers. (including renewal procedures)

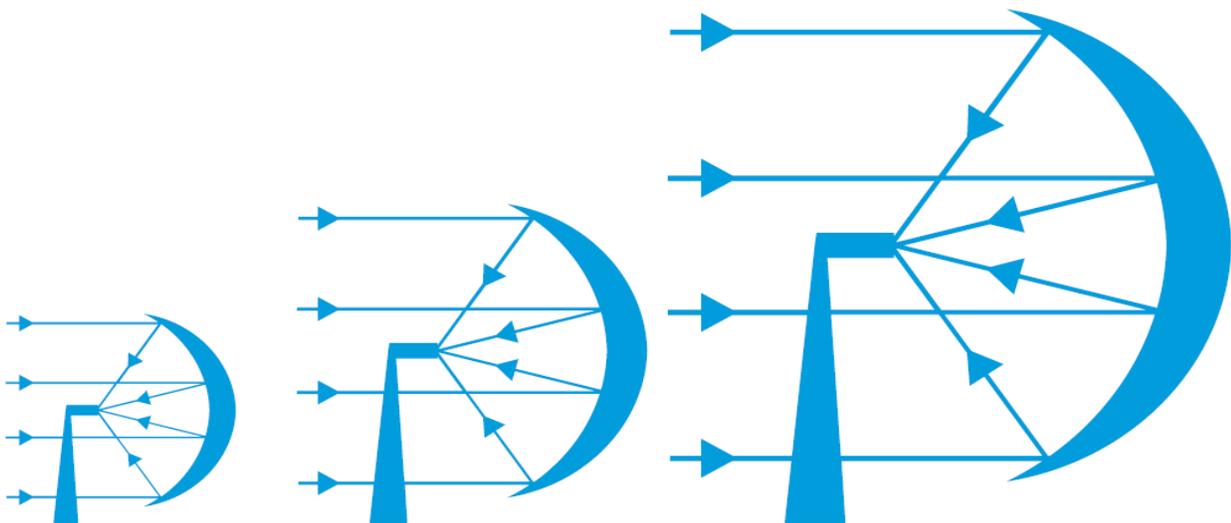
**Training and capacity building:** Conducting workshops for suppliers for knowledge transfer w.r.t. familiarity with latest guidelines and IBR mandates

# Table of Contents

<b>Executive Summary</b> .....	<b>3</b>
<b>1. Review of boiler regulations and acts</b> .....	<b>6</b>
1.1. Background .....	7
1.2. Review of key sections for solar thermal under IBR: Preliminary regulations.....	7
1.3. Current inspection and certification procedures .....	11
<b>2. Key challenges in IBR compliance and recommendations</b> .....	<b>14</b>
2.1. Exemption/Relaxations for CST Steam Boilers .....	14
2.2. Training and capacity building.....	14
2.3. Creation of a special channel within IBR for measuring CST steam boiler compliance.....	16
2.4. Miscellaneous .....	16

## List of Figures

Figure 1: Key aspects on platform .....	7
Figure 2: Physical, mechanical and chemical properties of manufacturing process .....	8
Figure 3: Mountings and fittings attached to the boiler .....	9
Figure 4: Registration and inspection process for boiler .....	12
Figure 5: Training and capacity building areas for CST suppliers.....	15



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# List of Abbreviations

CBB	Central Boiler Board
CM	Centi Metres
CST	Concentrating solar thermal
GA	General arrangement
IBR	Indian Boiler Regulations
KG	Kilo Grams
MNRE	Ministry of New and Renewable Energy
NISE	National Institute of Solar Energy
NOC	No Objection Certificate
UNIDO	United Nations Industrial Development Organization



# 1. Review of boiler regulations and acts

## 1.1. Background

Concentrating Solar Thermal (CST) is a system through which heat is generated and supplied to use for applications such as process heating, cooking, water heating, chilling system, etc. Several applications of CST entail steam generation for application in commercial or industrial sectors. As per definition of (The Boiler Act 1923 amended in 2007) given in act 2(b):

*“Boiler” means a pressure vessel in which steam is generated for external use to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel,*

- with capacity less than 25 liters (such capacity being measured from the feed check valve to the main steam stop valve)
- with less than one kilogram per centimeter square design gauge pressure and working gauge pressure; or
- in which water is heated below one hundred degree.

**If a CST system is generating steam and total system water holding capacity exceeds 25 liters and pressure is more than 2 bar (1kg/cm<sup>2</sup> gauge) absolute, then the steam generator is treated as a boiler as per Boiler Act 1923.** Its components have to be fabricated as per regulation I.B.R. 1950 with latest amendments regulations. Manufacturing of boiler & boiler components, registration of boilers and operation have to be followed as per various chapters given in Indian Boilers regulations 1950 as per provision of subsection of (1) of section 31 of Indian Boiler Act 1923 (amended in 2007).

## 1.2. Review of key sections for solar thermal under IBR: Preliminary regulations<sup>1</sup>

The government of India provides a reliable source of information focusing on the key regulations, series of amendments and other relevant updates in a holistic manner, which can be used by CST manufacturers to ensure compliance. These aspects cover the following key areas.



Figure 1: Key aspects on platform

The preliminary regulations involving manufacturing, inspection, use of boiler, boiler material and related boiler components critical for CST-IBR compliance have been analyzed in this section through various chapters of the regulation.

### Chapter I:

It covers general requirements, standard requirements, exemptions related to material, construction and operation of boilers. Procedure for recognition of new terms like competent authority, material testing laboratories, well known steel makers, well known tube makers, well known foundry, etc. are also part of this chapter. Key regulations part of this chapter include:

- Regulation 3 (4), (4A): Regulations will help solve problems related to manufacturing of boiler as per other code.

<sup>1</sup> refer the website [https://dipp.gov.in/sites/default/files/boiler\\_rules\\_updated/index1.htm](https://dipp.gov.in/sites/default/files/boiler_rules_updated/index1.htm) for the complete list of amendments and regulations

- *Regulation 5,5A: Regulations will help to solve problems related to use of material without test certificate after satisfying requirements of Inspecting Authority.*

**Chapter II:** This chapter lays special emphasis on ensuring superior quality of performance, with special emphasis on the mechanical, chemical and physical properties, including the manufacturing process itself. Key attributes include the following.

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Material requirements

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Manufacturing process

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Chemical composition

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Mechanical properties

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Defects testing

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Mechanical testing, hydraulic test requirements at manufacture place

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Heat treatment

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Tolerances

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Selection of material suitable for design temperature

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Welding, test coupon required for shop welding, welding testing, etc.

*Figure 2: Physical, mechanical and chemical properties of manufacturing process*

### **Chapter III:**

This chapter is useful for manufacturing of shell type fired boiler. It covers manufacturing of shell, weld seam details, end plates, hemispherical, dished end plates, stiffener plates, manholes, mud holes, etc. The key regulatory guidelines include the following.

- *Regulation 101: No boiler plates shall be less than ¼" in thickness.*
- *Regulation 164: Size of manhole/cleaning hole is given, which is required for steam and water drum.*

### **Chapter IV:**

This chapter mentions the calculations of working pressure of various pressure parts other than fusion welded and forged drums (Riveted construction type boiler). Key regulations to be adopted include;

- *Regulation 189: Dished end subject to internal pressure can be used for generator portion.*
- *Regulation 190: Dished end subject to external pressure can be used for generator portion.*
- *Regulation 200: Flat plate margin can be used for typical design with combination of dished end as per regulations 189 and 200 with plain cover*
- *Regulation 208; Bolts and Nut for externally fitted covers.*

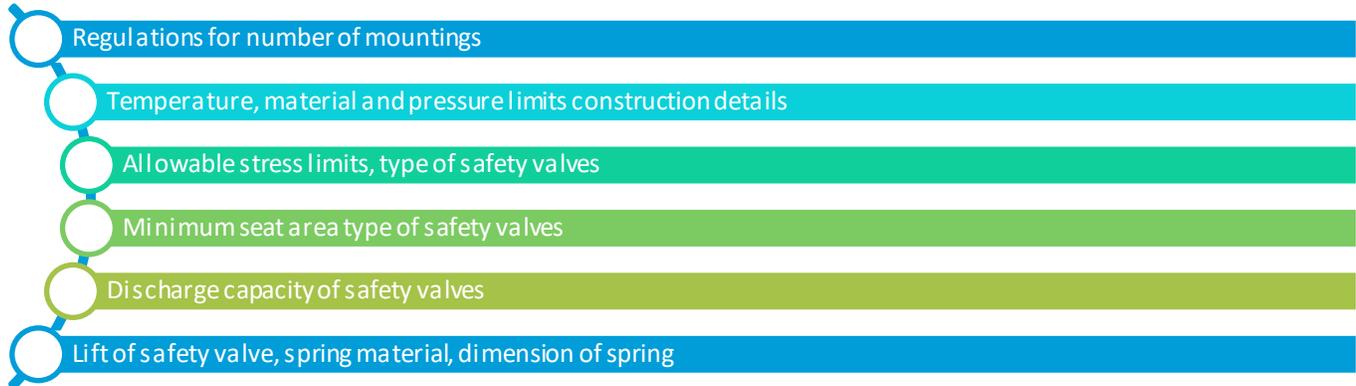
**Chapter V:** This chapter is important for water tube boiler and superheater and needs to be applied with Chapter I and Chapter III. It includes the following key technical aspects.

- Manufacturing of steam and water drum.
- Its welding joints, circularity, tolerance
- Removal defects in weld
- Weld test plate coupon,
- Non destructive test
- Removal defects in weld defects
- Heat treatment
- Hydraulic test.

The key regulations in this regard, include the following.

- *Regulation 270: Drum or shell working pressure*
- *Regulation 272: Ligament Efficiency*
- *Regulation 275 and Regulation 277: Dished end shape and dished ends with opening.*
- *Regulation 278: End plate subject to concave side pressure*
- *Regulation 279 and Regulation 280: For stand pipes and attachments/branch pipes figures*

**Chapter VI:** This chapter is only for mountings and fittings attached to boiler. It covers the following key attributes.



*Figure 3: Mountings and fittings attached to the boiler*

The following regulations should be thoroughly studied by CST manufacturers to ensure compliance.

- *Regulation 281:*
  - a) *Two nos. of safety valves suitable for relieving of generated steam per hour. Minimum seat diameter 19mm. Additional safety valve is needed for superheated steam.*
  - b) *Two means of water level indicators*
  - c) *Team stop valve*
  - d) *Feed water check valve*
  - e) *Blow down cock or valve*
  - f) *A manhole*
  - g) *No of Feed apparatus as per heating surface of boiler or equivalent heating surface to the evaporation given by manufacturer*
- *Regulation 281A: For automatic boilers*
- *Regulation 293: Cross section area of safety valves for saturated steam, superheated steam.*
- *Regulation 309: Determination of spring pressure.*

## **Chapter VII**

This includes regulatory guidelines for superheater tubes, headers and for other parts. The key regulations include the following.

- *Regulation 338: Working pressure for tubes can be used for circulating piping.*
- *Regulation 342(a) and 342 (b)(For working pressure of cylindrical headers same as Regulation 270. And for end plates same as regulation 340.*

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## Chapter VIII

The following attributes are discussed in this chapter:

- Pipe connected to boiler or part of boiler, considered for manufacturing process,
- tests, heat treatment design pressure.
- Flanges type, heat treatment after welding like stress relieving normalizing weld joints.
- Blow down pipes
- Pipe fittings and connections.
- Steam receivers, Accumulators

The key regulatory aspects include the following.

- *Regulation 351: Cast steel pipes material and working pressure*
- *Regulation 361A: Butt welding fitting*
- *Regulation 362: with all figures required for fabrication purpose.*
- *Regulation 366: For working pressure of shell defined in this chapter like receiver etc.*

## Chapter IX

- For registration of boilers, inspection of boilers and steam pipes – Regulations 376 to 385 are critical.
- Regulations 390 to understand how the inspecting officers are inspecting the boiler annually or biannually.

Regulation 393 to Regulation 395.

**Chapter IXA:** Safety of Persons inside the boiler: In the safety precaution to be taken by user at the time offering the boiler for regular inspection

**Chapter X:** Electrode Boilers

**Chapter XI:** It covers standard condition for design and construction of economizer and other similar vessels

**Chapter XII:** This chapter separately covers package type boiler. Total boiler is shop fabricated, tested and can be directly transported to user's place. In CST type of design, we can design and construct the steam and water drum or steam separator shell with minimum cost compared to the shell of water tube boiler with dished ends by using plain end plate supported by gussets, long stay bars.

In this chapter classification of fusion welded boiler is given in Regulation 363 as limitation on shell diameter plate thickness. Using regulation as per requirement of design pressure manufacturing cost of shell can be reduced. (class I, class II, class III pressure no limit, 105 pounds per square inch, 30 pounds per square inch respectively)

- Regulations 535 to 543: for preparation of construction as per design.
- Regulation 544: For circularity of shell
- Regulation 533: For manhole or access hole size
- Regulation 554: For manhole frames
- Regulation 554A: For internal door
- Regulation 559: For types of welded seams
- Regulation 561: For Tests on welded seams covers class I boiler, class II boilers, class III boilers
- Regulation 562: For heat treatment
- Regulation 563: For working pressure of shell
- Regulation 566 to 572 various types of end plates of shell

- Regulation 574: For flat end plate with stayed supports (For CST can be used)
- Regulation 591: For Gusset stay,
- Regulation 592: For furnace design

**Chapter XIII:** For welders test for manufacturing, repairing, etc.

**Chapter XIV:** For small industrial Boilers {this regulation made under clauses (a) and (aa) of section 28 of Indian boiler Act 1923 for small users}. This boiler suitable for single mirror CST due to high water holding capacity for shell type boiler 500 liters water holding capacity 7 kg per square centimeter pressure. For water tube boiler 200 liters water holding capacity at 12 kg per square centimeters. With combination of both types pressure is up to 7 kg per square centimeters and water holding capacity is 500 liters.

For operation of this boiler a certified Boiler operator Class II or 1st class is not required. Only 10<sup>th</sup> Standard Pass worker is required.

Regulation 619: Definition for above types

**Chapter XV:** Feed water for boiler

- Appendix A: For riveted boiler joints
- Appendix B: For tensile test pieces
- Appendix D: For proof test
- Appendix E: For Flanges, valves and fittings
- Appendix F: For Transverse rupture stress
- Appendix J: For Inspection and testing of boiler during construction
- Appendix JA: For Power utility boilers up to 20 years age and more than 20 years of age
- Appendix JB: For Waste boiler up to and more 20 years of age.
- Appendix L: Safety valve discharge testing

### 1.3. Current inspection and certification procedures

With regards to the procedures for manufacturing of components/pressures part of boiler in workshops, certain guidelines and documentation work has to be conducted by the CST manufacture to ensure compliance.

- Approval of drawings (**Regulation 4©(iii)**) with figures given as per regulation in between **XII 1 to XII 95** for each pressure parts and G.A. drawing from Inspecting Authority
- Offering material of construction for inspection to Inspecting Officer (competent person) with material test certificates in forms given below and identification mark of manufacturer.
  - **Form III B** for tube inspection,
  - **Form IIIA** for pipe inspection,
  - Form IV for plate,
  - **Form III-1** for dished end or end plate
- Offering weld fit up whenever is required with weld test coupons.
- Approval of radiographic /NDT reports of weld joints as per requirements.
- Final inspection/hydraulic test/stamping /as per requirements.
- keeping the records of above stages signed by inspecting officer or competent person.
- Preparation of makers papers certificates in format of following forms
  - **Form II(2)** for site assembled boiler,
  - **Form III** for certificate of manufacturer and test

- **IV- Form A** certificate of manufacturer and result in Liew of original test certificate given sr. no 2 and manufacturing drawings duly signed by Inspecting Authority.
- For all mounting certificates in **form III-C** given by mountings manufacturer

The overall process for registration and inspection of boiler has been presented below.

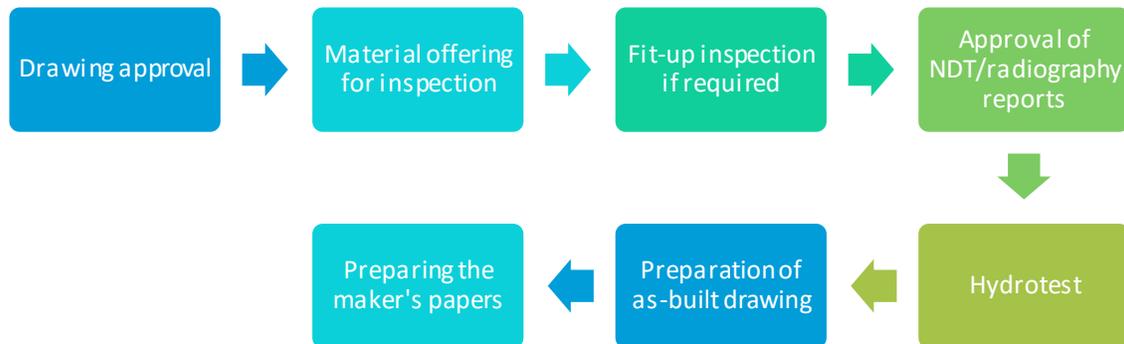


Figure 4: Registration and inspection process for boiler

There are two types of boilers as per construction and registration inspection point of view.

- ✓ Package boiler in which boiler is manufactured at manufacturers place as a one unit and it can be transported as a one unit and be registered at client's workshop in minimum 2-3 stage inspection (officers visits)
- ✓ **Site constructed boiler (CST unit boilers are covered in this category) in which different components of boilers are separately manufactured at manufacturers or vendors workshop with drawing. All manufacturers data including material specification details etc. is compiled in certificates in form II, III, IV as defined in IBR1950 with as built drawings, which is called as a maker's papers certificates in form II, III, IV.**

For a site constructed boiler, with these maker's papers, boiler will be registered at users place with guidance from concerned state inspecting authority (Govt. authority). The number of stage/ inspection visits by authority required ranges from 8- 100, depending on the type of boiler (water tube boiler to super critical boiler).

**In case of C.S.T. type boiler 8 to 10 visits will be required due to following:**

- *Inspection of all components on ground for checking the transport damage and cross-checking of components as per drawings and maker's papers. (if all parts are available at site)*
- *Tack weld preparation of pressure parts if required.*
- *Approval of radiographic reports/NDT reports as per regulations.*
- *Hydraulic test of total fabricated unit as defined in IBR 1950*
- *Obtaining Provisional order to operate the boiler in **form V***
- *Steam test of safety valve during operation for testing of safety valves for lifting, resetting*
- *Issue of certificate in **form VI** to operate the boiler for one/two years*

Accessories, mountings fittings are directly mounted on boiler for safety use of boiler and isolation of boiler from battery of boiler or users' stations. Minimum requirements regarding mountings are given **chapter VI of IBR 1950**.



## 2. Key challenges in IBR compliance and recommendations

The IBR regulations have posed some roadblocks in the deployment of a few large-scale CST systems for boiler applications. However, there have also been cases wherein there is lack of technical know-how on part of CST manufacturers about the procedures and guidelines to be followed for different components. These challenges and solutions have been analyzed in detail in the sections below.

### 2.1. Exemption/Relaxations for CST Steam Boilers

With regard to exemptions/amendments in existing IBR framework, the following recommendations have been developed on account of discussions with manufacturers and practical feasibility of their incorporation in the existing framework.

- ✓ Manufacturers of CST systems can put up the case with Central Boiler Board (CBB), keeping safety in mind regarding exemption of CST boiler having particular steam generating capacity and pressure for increasing operation period certificate time to 2 years just like that of power plant boiler/captive boiler given in chapter IX regulation 376 (ff),(fff) as per appendix JA, Appendix JB.
- ✓ For positive circulation boiler like parabolic trough design, use of metallic below hose pipe design of any international code to be incorporated in IBR 1950.
- ✓ For CST boiler designed and operated below 1kg/cm<sup>2</sup> gauge (2 bar absolute pressure as per steam table), it can be operated as steam generator not defined as a boiler as per Boiler Act 1923. In this case it is better to get N.O.C. from concerned state authority with submission of undertaking of not operating system above 1kg/cm<sup>2</sup>-gauge pressure and with verification by authority. But the roadblock is that the flow of steam at this pressure may affect the performance of the steam generator.

It is essential that any sort of relaxation in the IBR should be made, keeping in mind that the safety attributes of the system are not compromised. Few CST manufacturers have had issues owing to non-fulfilment of the IBR criteria w.r.t components such as safety valves and piping, which are critical to ensure safety (if safety valve gets stuck up, pressure can rise indefinitely causing explosion). Hence, manufacturers need to strictly adopt the IBR for certain components to ensure health and safety of the environment.

*As per one of the leading CST players, for Scheffler dish, installing new safety valve design (2 instead of 1 originally designed) was a big challenge. Performing the IBR cutting and welding process again on-site posed problems.*

### 2.2. Training and capacity building

During stakeholder consultation process, one of the biggest gaps realized hindering the IBR compliance is the lack of technical knowledge amongst CST suppliers, primarily on IBR regulations and associated caveats during manufacturing, erection and inspection process. In fact, many of the CST players outsource technical aspects related to compliance to third party agencies/consultants/manufacturers, who themselves are not aware about the scope of IBR, recent amendments which have been made over the last two decades and possible relaxations that can be provided on a case to case basis. Moreover, to ensure 100% compliance with IBR, the CST players have to make necessary modifications in their systems (on-site), basis inspection done by the state boiler inspection agencies which leads to additional costs and lot of hassle for beneficiaries opting for smaller system designs.

The key point to note here is that there is a high degree of flexibility in the technical specifications of components (such as material thickness) that can easily be relaxed under IBR, basis a thorough presentation of the technical case for adoption. However, the lack of awareness amongst beneficiaries, manufacturers, supplier, third party agencies about the recent developments requires immediate attention to improve overall industry experience.

*As per one of the leading CST player, going for IBR certified pipes for smaller systems, the cost almost doubles and the market is so sensitive that the clients are not willing to pay*

In this regard, it is suggested that periodic training and capacity building sessions be organized by MNRE in partnership with UNIDO, to improve industry experience with IBR compliance. The key areas where specific sessions would be needed include the following.

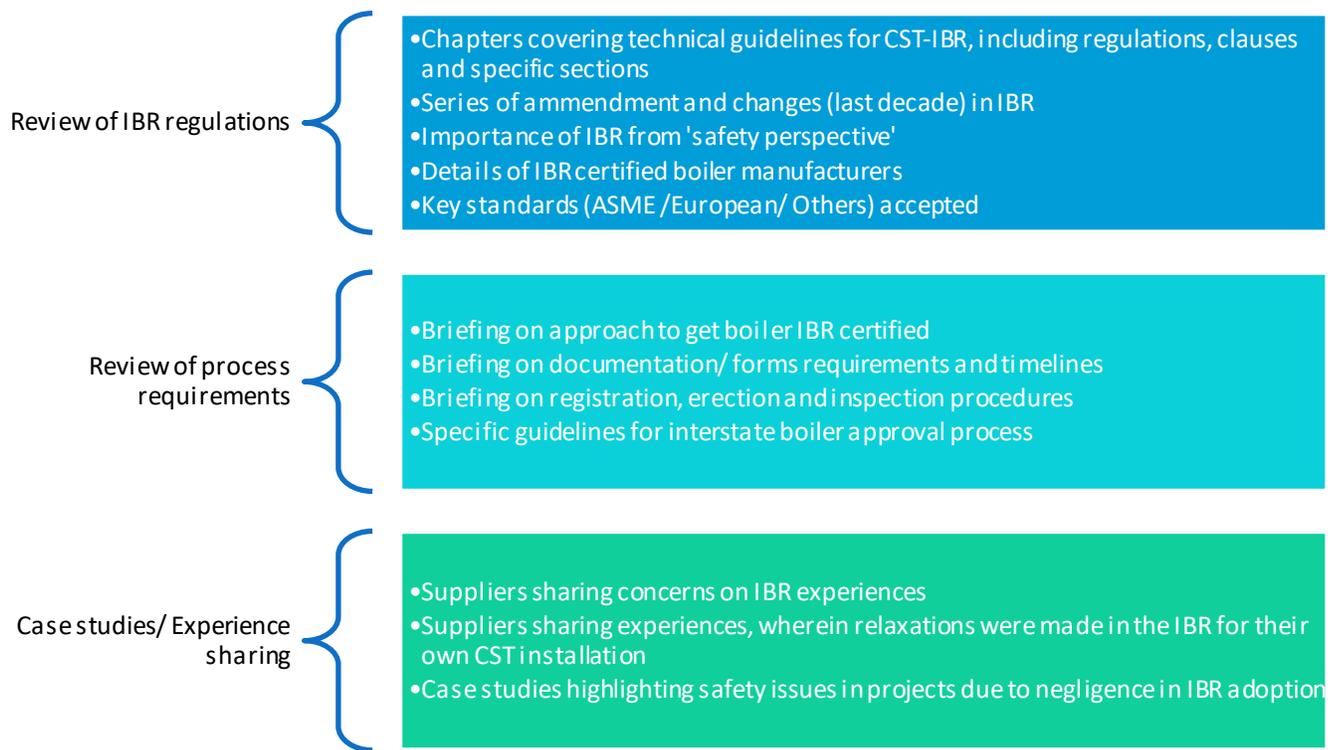


Figure 5: Training and capacity building areas for CST suppliers

*As per one of the leading CST players, many rules in the IBR seem to be redundant from any boiler perspective. The kind of metal thickness that is asked for in IBR is not even asked for in European countries such as Germany*

*As per one of the leading CST players, having a dedicated skilled operator, who is IBR certified, commercially doesn't make sense*

Hence, it is suggested that a comprehensive training program wherein the suppliers, end-users of CST boilers are provided training on design, construction, registration, inspection, operation and maintenance of small solar boilers needs to be designed. Knowledge transfer and upgradation in these areas would reduce errors and save time spent in reworking on the processes involved and hence decrease in the overheads for the manufacturers and clients.

*As per one of the leading CST players, every boiler inspector undertakes its own assessment, leading to lot of conflicts in the permissions in case of interstate boiler approval. Additionally, newer and complex technology designs attract more scrutiny, hampering innovation.*

*As per one of the leading CST players, thresholds should be defined for CST steam boilers. Currently, what is there for conventional boilers is the same for CST ones. Relaxations needs to be built in.*

### 2.3. Creation of a special channel within IBR for measuring CST steam boiler compliance

As discussed in the preceding sections as well, there are no relaxation with respect to adopting the standard procedures for IBR compliance for CST/non-CST steam boilers. There is a common process with regards to registration, documentation requirements, approval and clearance guidelines, including inspection procedures. Hence, to streamline the process the MNRE needs to front end this issue by designing a special programme/action plan/separate procedure in consultation with CBB to reduce the hassles faced by CST players for IBR compliance. At its own end, the MNRE should also undertake an initiative to enlist all major third party IBR certified personnel/consultants (similar to empaneled CST manufacturers programme) to bring in greater transparency and clarity, so that smaller players can also engage with them for advice/recommendations to provide a level playing field and ensure greater compliance.

Additionally, the Ministry should undertake initiative to build in its own capacities in the field of IBR, by roping in third party training providers to enhance knowledge expertise. National Institute of Solar Energy (NISE) or other relevant stakeholders may also lack clarity and in-depth know-how about the IBR guidelines and certification process and they can also be included in training programs to subsequently guide suppliers.

### 2.4. Miscellaneous

- For fusion welded small solar boilers, radiography or stress relieving need not be made mandatory
- IBR forms to be filled maybe be reduced if all the certification protocols are being followed
- The manufacturers and end-users need to be aware that third party inspection has been approved and allowed for relevant parties such as TUV, Bureau VERITAS and Lloyds<sup>2</sup>.
- The scope of IBR regulations for CST steam boiler can be relaxed to mandate only boilers having larger systems, above a given dish area/pressure (such as dish area of installation/3-4 bar pressure) to make the process hassle free for smaller players, who face financing issues engaging third party consultants for ensuring IBR compliance.
- It is suggested that a thorough review of all the rules and regulations in the IBR is conducted in a periodic manner to identify all the redundant rules (valid for all kinds of boilers conventional/non-conventional), and accordingly design modifications/amendments.
- Training and capacity building of not only the manufacturers, but also the client/beneficiary is necessary to ensure that the client is aware whether the CST player is adopting IBR guidelines or not. Such vendor due-diligence activities are imperative to avoid harassment of beneficiary.

<sup>2</sup> <https://cib.assam.gov.in/sites/default/files/third%20party%20inspection.pdf>  
<https://pib.gov.in/PressReleasePage.aspx?PRID=1597636>  
<https://www.tuv-nord.com/in/en/services/indian-boiler-regulations-ibr-inspection/>

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- Inclusion of a variety of allowable materials which can be lab-tested for their properties, in the manufacturing of CST boilers need to be investigated
  - Whether reduction in the lead times of the whole manufacturing, inspection and registration process in a logical way so that Indian companies can compete on a global scale in terms of quality as well as price needs to be analyzed
  - Manufacturers and the IBR department need to come up with a solution to reduce the manufacturing cost of the CST boilers while also following compliance safety norms.



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