NEW REFRACTORY LINING DIRECTION AT JINDAL STAINLESS FeCr #1 AND #2 FURNACES

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ABSTRACT

Jindal Stainless is setting up a Greenfield integrated Stainless Steel project in the state of Orissa, India, which would involve the mining of iron, manganese & chrome ore for the production of ferroalloys and stainless steel in the melt shop and rolling mills. To meet the full requirement of power, Jindal Stainless will also be building a 500 MW captive power plant. This stainless steel plant will ultimately have a capacity of 1.6 million tons per annum. The operation of two 60 MVA ferrochrome furnaces has already started, and the production has stabilized. JSL expects to start the 125 MW power plant soon, followed by the construction of additional ferro alloys units of ferro-manganese and silicon- manganese.The aim of this document is to outline the performance of the Jindal #1 furnace, as well as elaborate on the #2 furnace installation. Jindal Stainless is confident that these furnaces will be able to last at least another 8-10 years with the ChillKote™ lining technology.

1 INTRODUCTION

Both Jindal #1 and #2 are 11.6m diameter FeCr furnaces installed with GrafTech ChillKote™ linings [1]. The Jindal #1 furnace is a 60 MVA SMS Demag furnace with a daily hot metal production of approximately 200 tons FeCr. This furnace was commissioned during March 2008 and has been showing exceptional operational and lining performance. The furnace was installed incorporating the GrafTech ChillKote™ lining technology. This technology has significantly improved the expected lifetime of this furnace after the failure of the big block lining before the performance guarantee period was reached. No significant wear could be seen. The Jindal #2 FeCr furnace was also rebuilt with this technology during December 2008. Figure 1 shows the current freeze lining configuration used on the #1 and #2 furnaces. Notable is that both these furnaces were originally installed incorporating conventional “big block” carbon technology. Unfortunately, this lining technology failed before the furnace guarantee period was met. Previous repairs were attempted as well prior to the complete technology change.

Figure 2 shows the new and improved GrafTech tap hole configuration that was installed for the first time at Jindal #1. Having the two carbon side blocks using GrafTech’s Smart Ram® RP20 ramming paste joints will enable fast and easy changing of the carbon front block and graphite sleeve, if needed. The ramming will also form the joint between the tap hole abutment and the physical tap block. When a front block or sleeve requires changing, only the applicable components will be broken out. No damage will be done to the remainder of the abutment as was seen at previous tap hole repairs on large SAFs around the world.

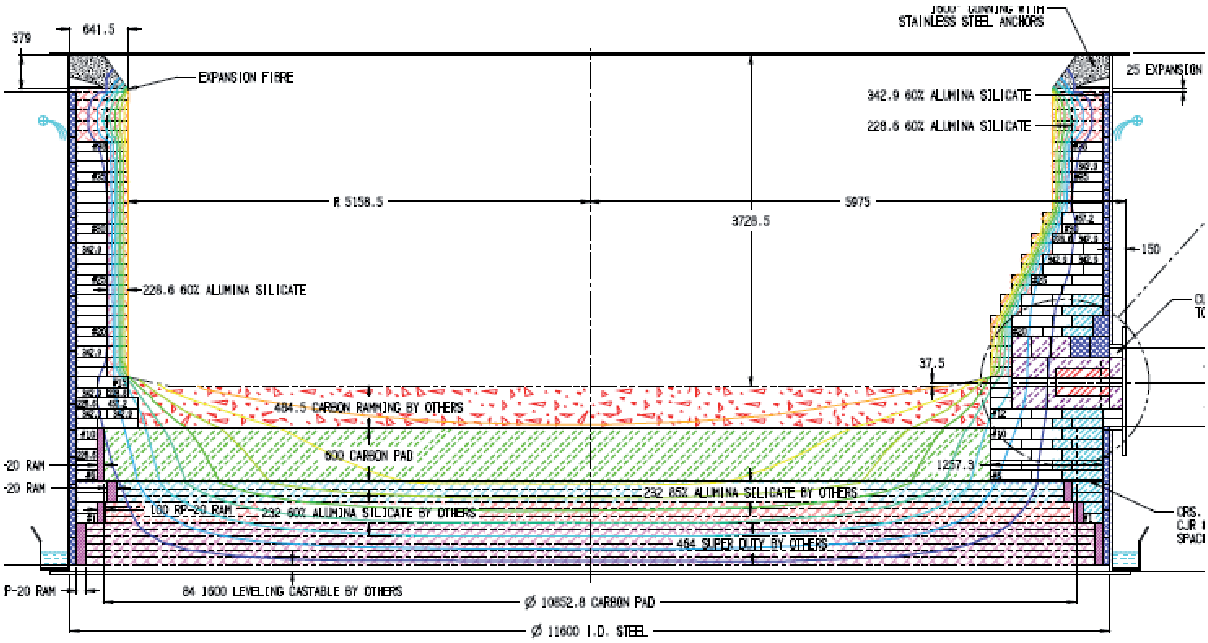

Figure 1: GrafTech ChillKote™ lining Jindal #2 (similar to Jindal #1)

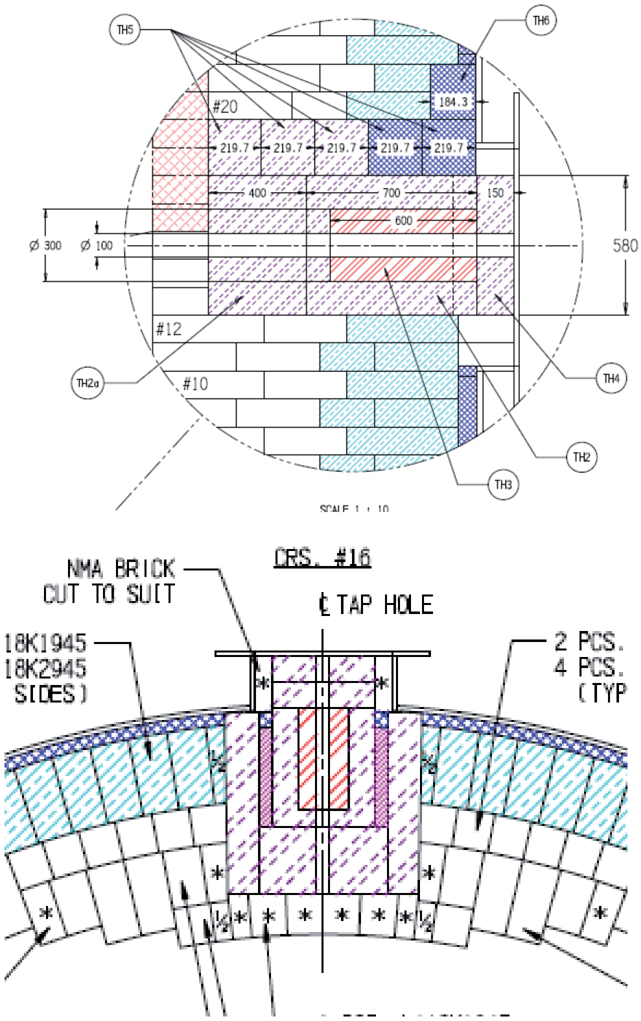

Figure 2: GrafTech improved tap hole configuration

2 MONITORING OF JINDAL FURNACES

In order to assist the Jindal Management team with monitoring their refractory lining temperatures, numerous thermocouples were installed in the hearth and sidewall on metal, slag and freeboard elevations. A thermal monitoring system was installed by South African firm AFC.

Dual type K thermocouples were installed 300mm and 150mm from the inside of the shell on the metal, slag and freeboard areas. Since start-up, the furnace has shown little significant increase in temperature due to lining wear. Figure 3 shows the trending of thermocouple 1 and 13 directly next to the tap hole. The trending looks very favorable as both the inner and outer thermocouples follow the same trend. Temperatures increased to just below 200 deg C during tapping but decreased again after tapping. Typically the outer couple temperatures should be more in the range of 300- 400 deg C. Thus we feel confident that the tap hole area is still in a very good condition. Although some lancing has been employed over the past year, we don't see any need to be concerned at this stage. However, more disciplined lancing procedures are recommended in order to extend this and any other tap hole life in submerged arc furnaces. It is advisable that the following four variables be checked regularly:

1. Drill lengths
2. Mudgun and drill availability
3. Lancing pipes used
4. Tap hole clay consumption

In a GrafTech refractory lining, the hot face temperature of the carbon bricks should always be less than 600 deg C to prevent oxidation of the carbon brick. Figure 6 shows the clover profile of the lining. Higher temperatures are seen around the tap hole and across the electrodes. This is expected in any submerged arc furnace, and the heat flux in these areas is also higher than between the electrodes. Higher temperatures can also be attributed to the loss of protective skull, electrode lengths and breaks and also power input. Spikes in temperature should be carefully analyzed. The most important aspect of lining management is that spikes should return to normal and trending should be steady over a period of time. Any increase over time in all thermocouples temperatures should be taken very seriously and the reason(s) should be identified and rectified.

Figure 5 shows the clover position at the slag line. It was noted that this profile is significantly different than the metal line clover profile. Thermocouples #8 and #6 across electrodes at back, in particular, showed temperatures higher than the rest of the thermocouples on the slag line. In such a case, the reason may be electrodes running at a higher position in the furnace, or as discussed above, loss of skull. The temperatures are still very low compared to typical hot face temperatures on similar FeCr furnaces worldwide, thus no reason for further investigation/preventive actions at this stage. This furnace is currently running at approximately 32MW input, which is at the limit of the furnace deign cacpity. Any MW input higher than this will also result in lining temperatures increasing in the sidewalls, especially across electrodes.

The freeboard area is normally the coldest part of a furnace and unless there are problems with furnace tapping, foaming or very short electrodes, this should not be an area for concern. On both #1 and #2 furnaces at Jindal an early 2010 inspection showed that these areas still had ceramics as well as steelwork perfectly intact, thus no reason for concern.

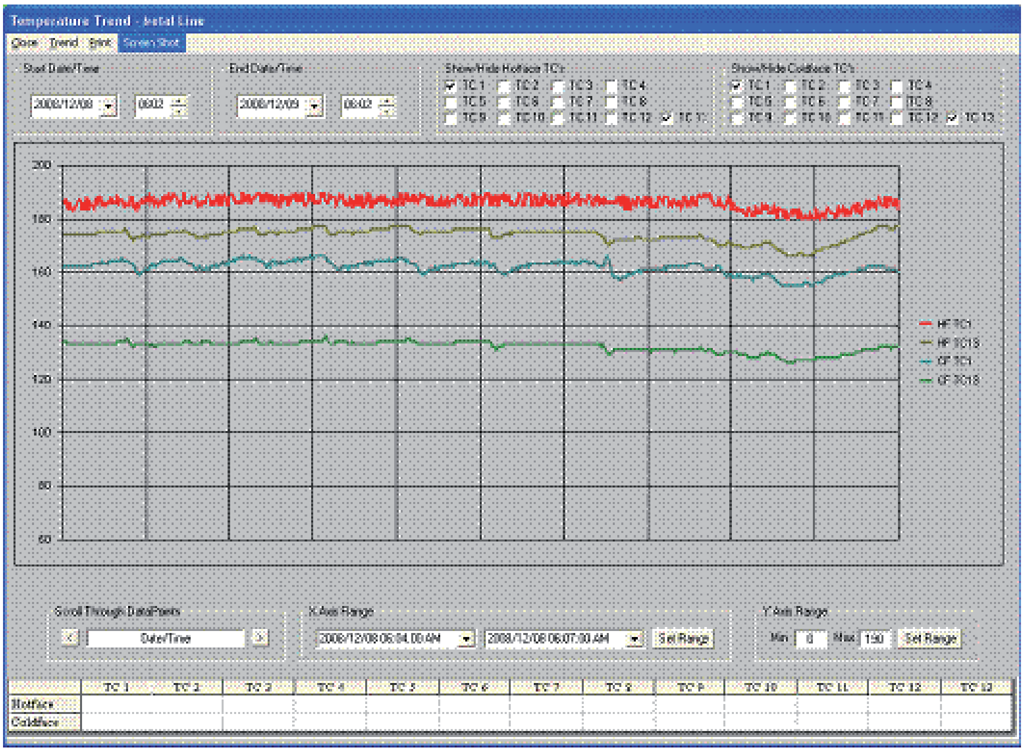

Figure 3: Trending of thermocouples 1 and 13 around tap hole varying between 120 – 200 degrees Celsius

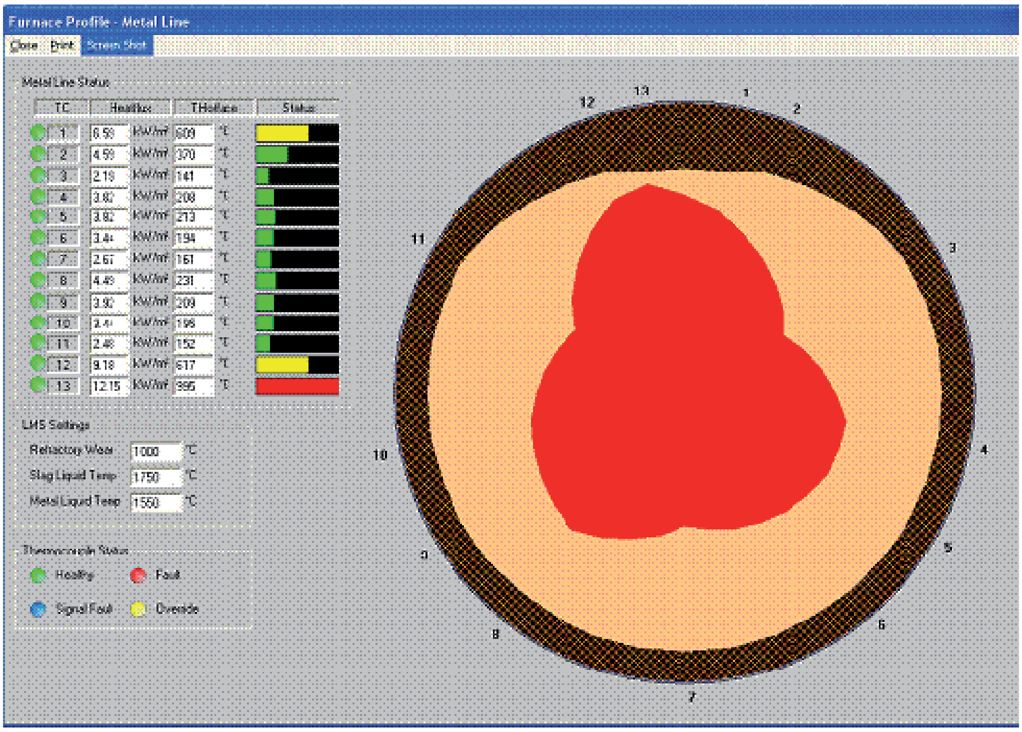

Figure 4: Clover profile at Metal line

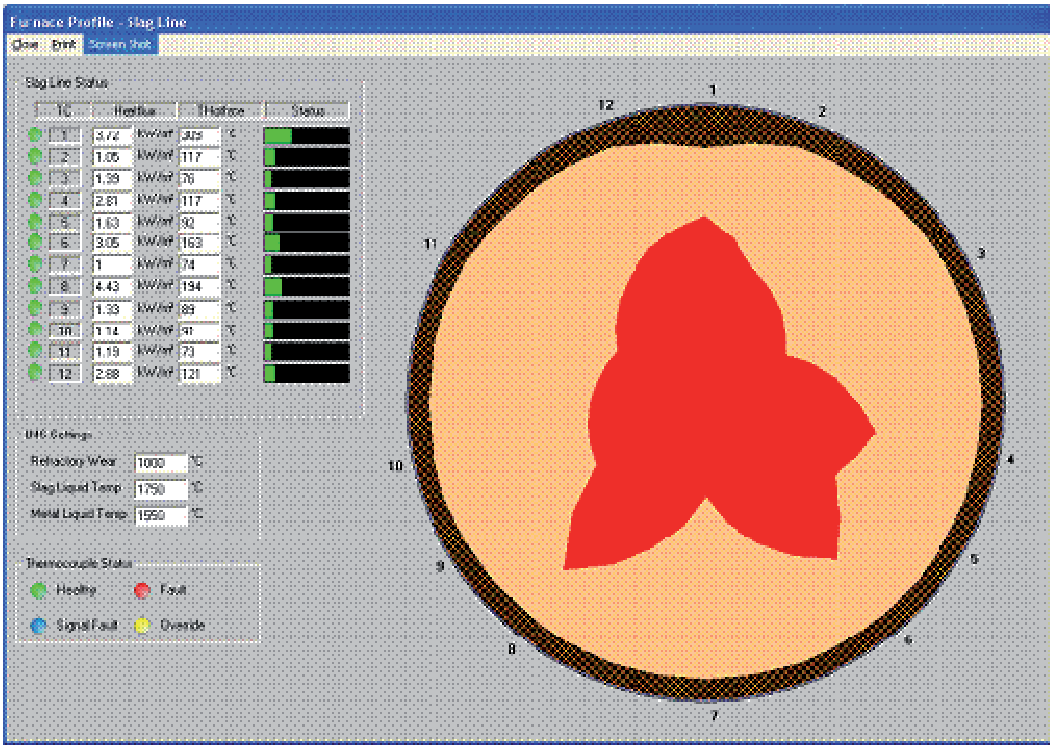

Figure 5: Clover profile at Slag Line

3 A DESCRIPTION OF THE GRAFTECH CHILLKOTE™ LINING CONCEPT

The Graftech ChillKote™ lining concept combines wall cooling and thermally conductive carbon and graphite refractories to "chill" the refractories by transferring heat away from the furnace lining [2]. Effective water sidewall cooling, together with the efficiency of the heat dissipating conductive refractories, lowers the temperature of the lining below that of the molten materials. This causes a layer of slag and process metal to solidify or "freeze" and forms a protective "skull" which completely coats the refractory hot face. Once formed, the slag skull insulates the refractories, reducing heat loss and protects the lining from erosion, chemical attack, thermal shock, and other stresses. The result: extended life and greatly improved refractory performance [4,5].

The ChillKote™ lining concept allows significant reductions in lining thickness and mass. As a result, the working volume and capacity of the furnace is increased, installation and commissioning time is shortened, and profit-robbing downtime is reduced. In addition, capital costs are lower. ChillKote™ linings combine engineering with low thermal resistant carbon, graphite, and semi-graphite materials with various ceramic refractories especially selected for thermal insulation, electrical insulation, and steel shell temperature control. Within a ChillKote™ lining, each component provides the properties required for its application and which work together in a cohesive system to enhance lining performance. An added advantage is that, should the protective skull be lost during upset conditions, self healing and the replacement of the skull will occur quickly due to the low refractory hot face temperature [6,7].

GrafTech's proprietary HotPressed™ method of manufacturing produces carbon and semi-graphite refractory bricks with low permeability, superior resistance to chemical attack, and outstanding thermal conductivity. GrafTech's HotPressed™ Bricks have an unsurpassed track record of reliable service in blast furnaces, direct reduction furnaces, cupolas, and submerged arc furnaces around the world.

4 INSTALLATION OF JINDAL #2

In order to ensure a quality installation, the following areas were seen as critical check points. Jindal #2 furnace was installed during December 2008, and is discussed in detail below. The same key inspections were conducted during the #1 installation in early 2008.

1. **Check the level of the shell plate at bottom and install a levelling castable**: Before any brickwork could commence, IRCI, as well as plant personnel, conducted a proper steel inspection. The bottom plate was not level, but this could be rectified by means of a ceramic levelling castable. The steel shell was not completely circular with numerous flat spots and all welding joints had to be grinded flush. Figure 6 indicates pouring of the levelling castable.

2. **Check shell for any obstructions and inspect welding joints**: Unfortunately, the steel shell was not in very good condition prior to installation. Flat spots were detected on the shell, which required additional field cutting of the HotPressed™ bricks. The steel shell was not perfectly circular, and horizontal and vertical joints had to be grinded flush. All existing mill scale, rust and dirt also had to be cleaned from the shell, as these are all potential barriers to effective heat transfer. The welding joints will normally be inspected via X-ray, as well as visual inspection.

3. **Levels of the alumina bricks and correct usage of alumina bricks**. On top of the levelling castable, 12 layers of Alumina bricks were installed, consisting of 6 layers of Super Duty Alumina Silicate, 3 layers of 60% Alumina Silicate and 3 layers of 85% Alumina silicate. An 85% Alumina powder was used as levelling to ensure a proper basis for carbon blocks. Jindal purchased all ceramic materials from domestic suppliers. GrafTech recommends which ceramic type should be used, but all QA compliance is the responsibility of the customer.

4. CBY **Graphite tiles packed closely against the shell**: Besides for some of the tiles on the horizontal and vertical welds, all joints were installed with a 1.7mm C34™ Cement joint. A slightly larger cement joint was expected when installing graphite tiles across welding joints and field cutting was required. Serrated trowels were used to “double butter” the cement, as well as the mallet used to enable proper contact.

5. **Ramming done tightly:** Between the alumina bricks and the tiles, and carbon beams and carbon bricks, a 100mm layer of Smart Ram® RP20 ramming paste was used. This served to aid with expansion, as well as thermal conductivity. This unique ramming paste contains special graphite flakes which expand at higher temperatures while at the same time increase thermal conductivity.

6. **Proper Installation of GradeD™ Carbon Blocks:** Floor blocks were installed with extreme care so as not to damage any of them. Blocks entered the furnace on rollers and were handled inside the furnace by means of crawl beam and hoist. GrafTech requires a 1.7mm cement joint between the carbon blocks. This ensures that good thermal conductivity can be obtained between all the blocks. To ensure this good contact, all blocks were jacked by means of wooden poles and steel beams as seen in figure 7.

7. **Check centre line of tap hole**: From the bottom plate, the centre line of the tap hole should have been 2134mm. This was confirmed after actual measurement. This distance is critical to ensure that the centre line of the tap block aligns with the mud gun and drill.

8. **Ensure that all carbon and semi-graphite bricks in sidewall and ring wall are installed properly, and cemented and jacked to ensure a 1.7m joint:** Figure 13 shows HotPressed™ NMD™ bricks (semi graphite) on the cold face and NMA™ carbon bricks on the hot face in the cut-out of the carbon pad. These bricks were properly jacked after double buttering and the joints checked with a feeler gage.

9. **Tap hole abutment installed according to GrafTech improved tap hole configuration:** Instead of only installing one carbon tap block, GrafTech has improved the tap hole configuration to improve lifetime and assist with changing of tap block during repairs. The new and improved configuration incorporates 2 carbon blocks instead of one solid block with a Smart Ram® RP20 ramming paste joints between two carbon side blocks. The RP20 will be broken out when changing a block, and the side blocks serve to protect the bricks in the abutment when break-out occurs. Instead, only the front block is broken out and replaced. This will also ensure shorter downtime while doing tap hole maintenance and repair. The new

and improved configuration can be seen from above in figure 8. Figure 9 shows the tap block and surrounding bricks as seen from outside of the furnace.

10. **Check for expansion paper in between alumina bricks in sidewall:** 60% alumina bricks are packed in front of the carbon bricks in the sidewall according to prior calculation to indicate amount and thickness required at variable temperature ranges.

Figure 6: Pouring of Levelling castable

Figure 7: GradeD™ carbon block in hearth showing proper jacking by means of jacks and wooden poles

Figure 8: New and improved GrafTech tap hole configuration

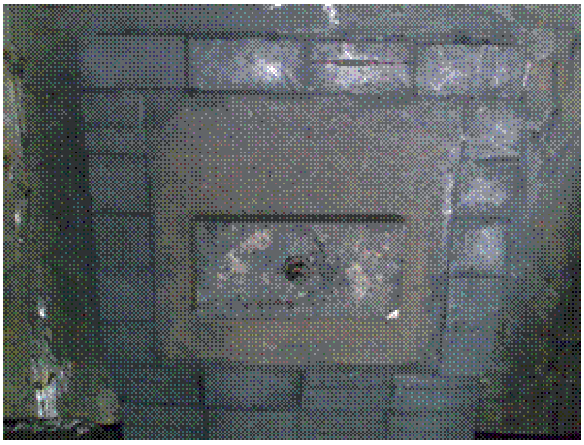

Figure 9: Tap block and surrounding bricks inside steel flange as see from outside of furnace

5 CONCLUSION

Jindal Stainless is investing heavily in adding new capacity at their newest ferro chrome plant in India. In doing so, they have decided to invest in state-of -the-art equipment, which includes the smelting furnaces. In this paper, we have shown how the refractory linings initially supplied with the furnaces failed prematurely and how these were replaced with the proven ChillKote™ lining systems. We have also shown details of the actual installation process, a vital and important ingredient in the formula for a long and successful furnace campaign. An advanced thermal surveillance system was installed and allows for Jindal operations management to closely monitor the condition of the lining and take immediate actions if and when abnormal situations occur.

6 REFERENCES

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