

## PROCESS SAFETY MANAGEMENT IN TATA STEEL EUROPE – THE APPLICATION OF PROCESS SAFETY THINKING TO A MATURE INDUSTRY AND HOW TO FOCUS ON PROCESS-RELATED RISKS

Allen Ormond<sup>1</sup>, Richard Roff<sup>2</sup>

<sup>1</sup>Principal Lead Safety Consultant, ABB Engineering Services, UK

<sup>2</sup>Group Process Safety Specialist, Tata Steel Europe, UK

Building on the implementation of improved arrangements for managing process safety within Corus, now Tata Steel Europe, [Ormond and de Klerk 2009], this paper describes the further progress made with particular regard to the pursuit of a structured and comprehensive programme to evaluate the process-related risks across the whole of its manufacturing operations.

An initial status review by ABB of the arrangements for managing process safety [Ormond and de Klerk 2009] had led to a safety improvement programme focussed on:

- identification and assessment of all process-related hazards on the operating sites beyond that already done under the Seveso II Directive;
- an integrated safety management system that includes pertinent standards for process safety;
- arrangements for monitoring process safety performance alongside those long-established for workplace safety.

The programme for identifying and assessing process-related hazards at Tata Steel Europe's top tier COMAH establishments using ABB's technique for process hazard review – PHR – was extended, as a pilot, to a non top tier COMAH establishment. This demonstrated that the technique is both effective and time efficient for all iron and steel making/processing activities like those undertaken by Tata Steel Europe.

Developing a structured and comprehensive programme to evaluate the process-related risks across the whole of its manufacturing operations was the next challenge. The pursuit of this by the Tata Steel Europe Group Process Safety Team with continued support from ABB is described, covering in particular:

- persuading the organisation that process-related risks matter and gaining the buy-in to PHR from the businesses;
- the development of a staged approach to PHR in Tata Steel Europe;
- the development of an internal capability to conduct PHR studies effectively in Tata Steel Europe through training and coaching.

**KEYWORDS:** Safety Management, Process Safety Leadership, Steel Industry

### INTRODUCTION

Tata Steel Europe (TSE) was formerly known as Corus. TSE is an international iron and steel company formed from the merger of British Steel and Koninklijke Hoogovens in October 1999, which was then acquired by Tata in April 2007. Its manufacturing operations are based in Europe and the US with major plants located in the UK, the Netherlands, Germany, France and Norway. The company manufactures carbon steel-based products and is Europe's second largest steel producer. TSE is organised into three regional manufacturing 'hubs' with a global supply chain function and customer industry sector-focussed sales and marketing groups. TSE is part of Tata Steel, a subsidiary of the Tata Group.

The background to the progressive focus on process safety in TSE has been described by Ormond and de Klerk [Ormond and de Klerk 2009] and is further described in this paper. An initial status review by ABB of the arrangements

for managing process safety had led to a safety improvement programme focussed on:

- identification and assessment of all process-related hazards on the operating sites beyond that already done under the Seveso II Directive [European Council 1999 and 2003];
- an integrated safety management system that includes pertinent standards for process safety;
- arrangements for monitoring process safety performance alongside those long-established arrangements for workplace safety.

In strengthening its corporate governance TSE established a new Health and Safety Management System that integrated process safety requirements and put in place a central function concerned with auditing. A central Group Process Safety team was also established, headed up by a Group Process Safety Director. Members of the team were

assigned both regional as well as specialist responsibilities covering all aspects of process safety management (PSM) pertinent to the company. Steps were also taken to make an initial site-wide assessment of process safety hazards and arrangements at Tata Steel Europe's manufacturing sites.

The programme for identifying and assessing process-related hazards at Tata Steel Europe's top tier COMAH establishments using ABB's technique for process hazard review – PHR – was extended, as a pilot, to a lower tier COMAH establishment. With the addition of some guide-word prompts to more effectively cover the nature of processes in iron and steel manufacturing, this demonstrated that the technique is both effective and time efficient for all iron and steel making/processing activities similar to those undertaken by TSE.

From here the company now needed to consider how the PHR methodology utilised and licensed by ABB could be adapted and applied most effectively across the whole of its manufacturing operations as well as the merits to the business of such an approach.

#### ABB'S PHR METHODOLOGY

PHR has been developed from the hazard study methodology that was itself developed in ICI [Turney 1991]. It is a methodology that is tailored for the identification and initial assessment of the more significant process-related hazards on existing plants so that this can be done in the most efficient manner. It takes due account of the operations experience and involves study meetings with selected operations and technical personnel that are essential for an effective study. A number of papers have been published on PHR (e.g. [Ellis 2005]) and only pertinent details will be covered here

ABB's PHR methodology involves two stages:

- an initial scope meeting;
- a structured hazard identification and assessment study using guidewords and associated prompts that are focussed on loss of containment hazards and how these might arise.

PHR is undertaken at plant level. However the scope meeting serves to capture a common understanding of the key issues to be considered in the study. In addition to:

- the hazardous nature and inventory of the dangerous substances;
- the nature of the types of incidents that can arise, and
- the broad level of risk mitigation measures established.

these include:

- the brief history of the operations;
- the vulnerable locations onsite and in the adjacent community (including the potential for domino effects);
- the potential harmful impact from externally caused events, e.g. flooding;

- the effects of general failure of utilities and fluid services, and
- the incident history.

Consequently on multi-plant sites the scope meeting covers issues that are usually common to all plants. The information and data produced during a scope meeting have been used to provide a reasonably objective means of prioritising a programme of PHR studies across different plants on a site in a coarse hazard-based manner. For TSE with its diverse spread of operations, both technologically and geographically, and its very large number of individual plants, such a prioritisation was particularly important.

The output from the PHR hazard identification studies covers:

- the description of the loss of containment scenarios and their most likely causes,
- their consequences, both immediate and ultimate,
- the safeguards that mitigate either the likelihood or severity of harm,
- the recommendations either for improvement or further assessment, e.g. fault tree analysis, more in-depth study of selected parts of the process by HAZOP and more detailed consequence assessment,
- an initial semi-quantitative assessment of the associated risk to aid with the prioritisation of action subsequently taken.

However, the PHR hazard identification study also provides the information to determine where further assessments should be focussed (see Figure 1), such as:

- demonstration that risks are as low as is reasonably practicable (ALARP)
- safety integrity level determination of all functional safety systems
- alarm management
- human error assessment of procedural arrangements and individual activities

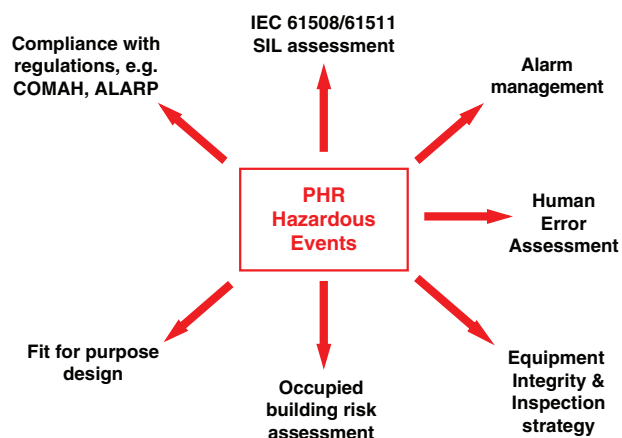


Figure 1. PHR – the gateway to risk reduction

- equipment condition monitoring, inspection and preventive maintenance
- occupied buildings onsite
- the integrity of operating, maintenance and emergency procedures
- equipment design standards.

For TSE, the overall approach to the identification and risk assessment of process related hazards needed to encompass all of these issues.

### ENGAGING LINE MANAGEMENT

As a subject, discussion of process safety was largely absent in TSE until the advent of Seveso II in 2000. Until that point no major-hazards legislation applied to steelmaking or other operations in the company. After that point, the integrated steel-making sites would have to submit COMAH safety reports, as would sites handling large quantities of hexavalent chrome compounds. A small number of other sites would be covered by COMAH at the lower tier and process safety management practices and expertise were generally confined to these ‘major-hazards’ locations and businesses.

BP’s Texas City Refinery incident in 2005 provided a catalyst to discuss process safety at the highest levels in the company; a senior member of the BP board at that time was a non-executive director of Corus PLC and he persuaded the Corus board of the need to consider the subject more holistically. This ultimately led to the inclusion for the first time of a number of process safety objectives in the corporate three-year safety improvement plan for 2008.

Whilst there was developing belief at senior levels in the company that process risks were important, it was clear that a wide-ranging lack of understanding had to be tackled and a number of approaches have been taken. A Group Process Safety Team was recruited from both outside and within the company. This team is distributed; each of its members has been allocated a regional contact role as well as custodianship of particular processes and expertise. Part of the early engagement was to visit sites and to discuss process safety with management teams. This allowed for some basic training but also for the completion of the most basic level of process hazards analysis as described below.

An introductory pamphlet – ‘What is Process Safety?’ was distributed to accompany the inclusion of corporate process safety objectives and this has been followed by a regular newsletter with articles on various process safety subjects. The circulation of this newsletter has been broadened continually and it continues to provide a forum to provide general information to line management.

For some years a group of experts from the COMAH registered sites had met to drive compliance activity towards greater consistency across the company. More recently, this has been extended to cover a wider range of process safety subjects and to include people from non-COMAH sites – from all of the UK high hazard facilities (HHFs). It now serves as an opportunity to share experiences, approaches and learning and for the Group Process Safety Team to

discuss forthcoming guidance within the evolving safety management system. The model has been extended beyond the UK with similar meetings held to cover HHFs throughout TSE.

TSE is a member of the World Steel Association, the international trade group of the iron and steel industry, and has taken leadership of the process safety focus group within this. This focus group includes representation from manufacturers in Europe, the US and India and is beginning to develop high level guidance on a number of topics in process safety management including leadership, auditing and self assessment, human factors, risk assessment and management, mechanical integrity, incident reporting (loss of primary containment), process safety information, incident investigation, molten metal – water interaction, management of change.

TSE has a safety management system comprising requirements under fifteen principles [Ormond and de Klerk 2009]. However, in order to inform debate about the need for a special focus on process safety an expansion of the ‘Heinrich’ [Heinrich 1959] or ‘Bird’ [Bird 1974] accident triangle model has been used; in place of a single accident triangle, there are two with some overlap between these at the base. This idea is described by Andrew Hopkins [Hopkins 2009] but has been developed in TSE with more description of each level of the triangle as shown in Figure 2. Within TSE consensus is developing on the need for separate guidance for the management of process safety, distinct from guidance for the management of personal safety but within a single set of principles embodied by the safety management system.

The gradual education of the organisation with respect to process risks has allowed the Group Process Safety Team to discuss the need for formal process hazards analysis (PHA). It was possible, with a small number of internal facilitators and with the help of ABB, to deliver a number of studies using the PHR methodology for ‘early adopting’ sites. The experience at these sites has been passed on to other areas of the business in order to build a pull for PHA through forums such as the HHF consistency group.

### THE DEVELOPMENT OF A STAGED APPROACH TO PHR IN TSE

After agreement with the Process Safety Steering Committee the Group Process Safety Team has proposed a set of ‘recommended process hazards analysis methodologies’ for legacy plant. The intent of the approach is to begin with a top-down assessment of the company and of each site in order to identify where PHA will be required and then to move into PHR as a specific methodology followed by more detailed studies only where these are needed.

The first stage of the assessment has been facilitated by the Group Process Safety Team and comprises a site visit and discussions with the management team to determine which locations in the company have process hazards. This is immediately followed by an assessment

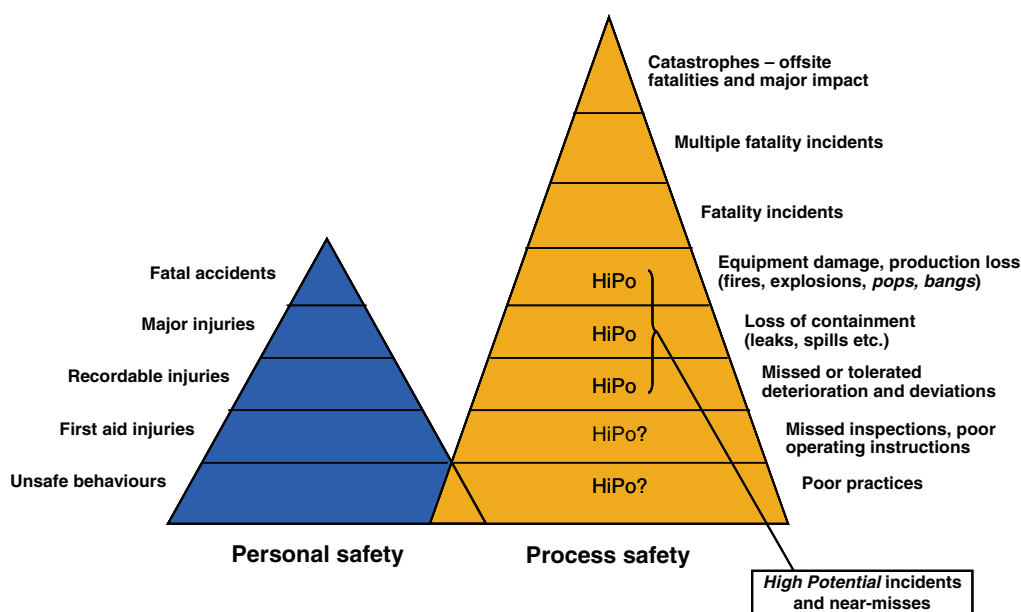


Figure 2. Accident triangles: Personal and Process Safety

of each plant or process at the location to focus subsequent PHA onto processes that require it. The process is referred to as High Hazard Facility (HHF) and High Hazard Installation (HHI) assessment and output is made consistent by the use of a simple recording tool in a spreadsheet for each location. The output of the HHF assessment is a list of the dangerous substances at the facility and their quantity, a list of the installations and a cross to where the dangerous substances are located. The dangerous substance list is based on the list in the Seveso II Directive [European Council 1999 and 2003] with the addition of molten metal and slag, high voltage electricity and the possibility of sudden release of stored energy.

The term 'facility' is intended to be the equivalent of 'site' or 'location' but in the largest sites the HHF assessment has been applied at a 'department' level. For example, a stand-alone mill is counted as a facility but in an integrated site, the blast furnace department is assessed separately from the steelmaking department, each as a 'sub-facility', though the record of the assessment is held at site level.

The term 'installation' can have a more flexible meaning depending on the organisational structure at the site. The intent is to identify where the process hazards are so that PHR can be focussed here. Examples of installations include the hot end of a mill; the effluent collection and treatment plant; the site rail network and the LPG storage tank.

By applying the same series of questions to each facility we determine and record that it is a Low Hazard Facility (i.e. does not have significant process hazards) or High Hazard Facility at one of four levels. A similar series of questions leads to Installations being classified as Low

Hazard Installation or High Hazard Installation at one of three levels. The definition of each classification is given in Table 1.

Within TSE, HHF assessment has been referred to as 'PHR0' and the company guidance directs us to apply PHR at all HHFs. This is the first stage of a broader requirement for rigorous application of process safety management in HHFs. After HHF assessment, we now have a prioritisation for sites and a prioritisation for the PHR programme on each site based on the HHF and HHI categories. This process has been applied at all manufacturing locations in TSE and it is intended that it be applied to all locations eventually to create a complete HHF register. At this time, the distribution of categories is as shown in Figure 3.

The next stage for sites categorised as HHFs is to build a programme for PHR. The scope study described above is referred to in TSE as PHR1 and the hazard identification and risk analysis is referred to as PHR2. The PHR programme includes time for collection of process safety information and for each stage of PHR and includes the need to secure trained and experienced facilitators. In the case of HHF1 sites, much PHA has already been carried out including PHRs, fault and event tree analyses, SIL assessments etc. These sites have used the HHI assessment to identify gaps in their programmes and then prioritise cyclic PHA. The output of PHR may be enough to define the basis of process safety for some sites, but in others further formal PHA will be required. In all cases site teams have to move to demonstration of risks at ALARP level and maintenance of the layers of protection identified through PHA. An overview of TSE's approach to recommended PHA methodologies is shown in Figure 4.

**Table 1.** Descriptions of HHF and HHI classifications

HHF1	Facility with quantities of dangerous substances greater than the upper threshold defined. This will include all facilities to which Seveso II directive applies at tier 1 or top tier.
HHF2	Facility with quantities of dangerous substances greater than the lower threshold but lower than the upper threshold defined. This will include all facilities to which Seveso II directive applies at tier 2 or lower tier.
HHF3	Facility which has dangerous substances or stored energy and which is sufficiently complex in terms of number of dangerous substances or processes (including management processes) that their interaction is foreseeable in or leading to an incident. This includes interactions with activities in neighbouring facilities.
HHF4	Facilities with one or a few dangerous substances or instances of stored energy which could be released so as to cause a major accident but which are not likely to interact in an incident and which are simple to store and process based on well proven techniques or systems.
LHF	Facility which does not have dangerous substances or stored energy; or Facility where the quantity of dangerous substances or nature of stored energy is such that a major accident is not reasonably foreseeable.
HHIA	Installation within a high hazard facility (HHF) that has more than 5% of the upper threshold defined of any of the dangerous substances and has potential to affect, or be affected by, surrounding installations or neighbouring facilities during or leading to a process incident; or Installation within a HHF that provides a process safety-critical service to any other HHIA.
HHIB	Installation within a HHF that has more than 5% of the upper threshold defined of any of the dangerous substances but with minimal potential to affect, or be affected by, surrounding installations or neighbouring facilities during or leading to a process incident; or Installation within a HHF that provides a process safety-critical service to any other HHIB.
HHIC	Installation within a HHF that has no more than 5% of the upper threshold defined of any of the dangerous substances and has 'processes' as defined; or Installation within a HHF that could cause injury to the public through loss of equipment integrity; or Installation within a HHF that provides a process safety-critical service to any other HHIC.
LHI	Installation which does not have dangerous substances or stored energy; or Installation which has no 'processes' and where the quantity of dangerous substances or nature of stored energy is such that a major accident is not reasonably foreseeable.

### COMPETENCIES NEEDED TO CONDUCT PHR STUDIES & THEIR DEVELOPMENT

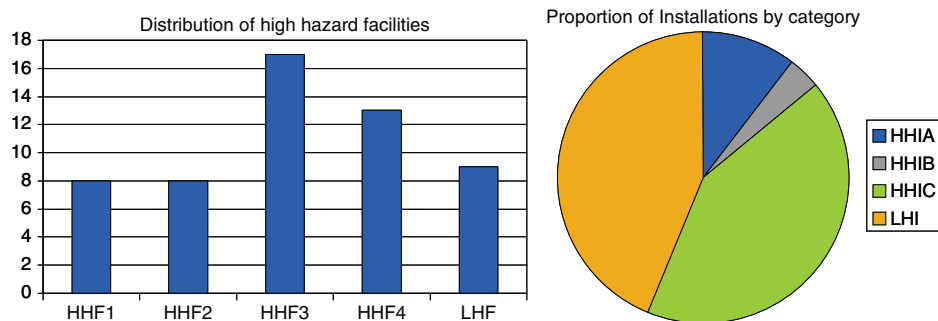
Of greatest importance to the effectiveness of any hazard study is the experience and knowledge of the study leader and the study team [Ormond 1995]. Like most hazard study techniques, one of the key values of PHR is that it is a team-based study, gathering together people with relevant knowledge and experience in order to bring out the best means of identifying and assessing potential hazards, facilitated by the study leader.

A PHR study leader should possess several years experience in either plant/process operations management or support so that he/she is knowledgeable of typical

arrangements for managing safe operations and is aware of human factors in a practical context.

Experience in risk management arrangements/techniques should include for example, hazard analysis, consequence modelling, process safety management and auditing. A working knowledge of pertinent International standards and regulations relevant to process safety, an understanding of how areas such as mechanical integrity, environmental impact/risk assessment, alarm management, SIL verification and hazardous area classification relate to process safety safeguards is particularly beneficial.

It is also important that the PHR leader needs to be able to exercise skill and judgement over when and how

**Figure 3.** Facility and installation classification data

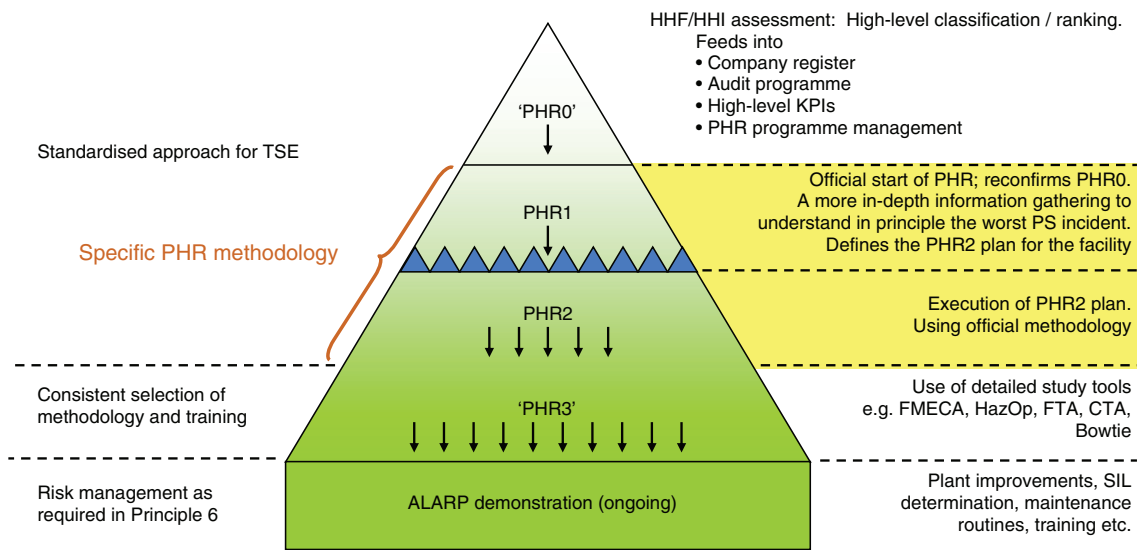


Figure 4. Recommended PHA methodologies in Tata Steel Europe

to vary the focus of the discussions for an effective study. Technical training in PHR, can be achieved via a training course that extends the knowledge and understanding provided by standard HAZOP training. However, development of the skills and competencies to facilitate PHR meetings effectively requires a period of coaching and mentoring, largely bespoke to the trainee.

Experienced HAZOP leaders with appropriate experience in plant/process operations are most suitable to develop competence in PHR.

ABB practice a formal and structured hazard study leader accreditation system in order to assure the competence of all its hazard study leaders. This accreditation system takes account of foundation technical skills and knowledge as well as experience-based skills that are developed and honed through coaching and mentoring from experienced leaders and with regular practice. ABB has integrated the particular competence requirements for PHR leadership into this accreditation system. An overview of the training and development programme in PHR leadership pursued by ABB is shown in Figure 5.

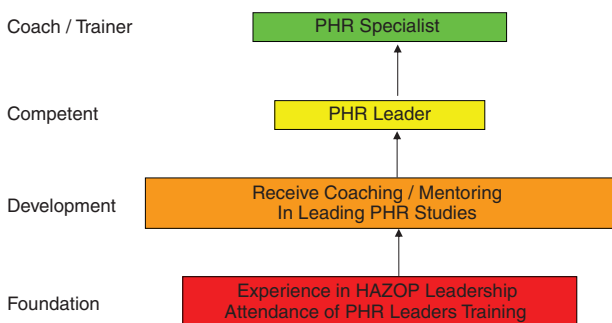


Figure 5. ABB training & development programme in PHR leadership

**AN INTERNAL CAPABILITY TO LEAD PHR STUDIES IN TSE**

Having made a decision to base TSE’s approach to PHA on PHR it was clear to the Group Process Safety Team that the company should build an internal capability to facilitate these studies; this would allow TSE to build up and retain the knowledge gained during studies in-house and to spread this through the company more easily. This argument was very easily made to senior managers as an industry downturn was putting pressure on costs. The more important argument at the time was that in-house facilitators had to have the right experience, attributes, training and time to deliver thorough, consistent and useful studies.

Ultimately, it is expected that relatively few PHR facilitators will do this on a full-time basis and that most will make time within another role. Since many of these facilitators will be within the operations or engineering teams, a further benefit is that they can act as champions for process safety at their location.

As has been described above, PHR should be facilitated by competent practitioners who have both a good understanding of process safety hazards and risk, and significant experience of manufacturing operations. TSE has chosen, therefore, to ‘licence’ its PHR leaders with several stages required to gain accreditation. Accreditation of PHR leaders will ensure consistency of approach and outcomes and it will apply to TSE staff and to any consultants that we may retain for this service.

In order to become an accredited PHR leader in TSE, a person must meet these criteria:

1. They must have experience in at least one of the following:
  - Operations or technical management or support in HHIs (>5 years);

- Engineering or maintenance management or support in HHIs (>5 years).
2. They should then also have one or more of the following experiences:
    - process safety consultancy (>5 years);
    - several high hazard processes;
    - several industries.
  3. They must be trained in the specific PHR methodology via a course organised through the TSE Group Process Safety Team.
  4. They must have observed a number of PHRs (perhaps as 'scribe').
  5. They must have led a number of PHRs successfully under guidance from a more experienced PHR leader.

Based on these requirements, a number of candidates have been selected from the business for training. This training has been delivered by ABB under the auspices of the Group Process Safety Team. Records are retained centrally of the experience of TSE leaders and each is then asked to make a return of their experience in scribing and leading PHR on a regular basis.

When only a few TSE leaders had been trained, early experience was gained through attending and assisting ABB facilitated PHRs; more recently it has been possible to gain experience through facilitating with other in-house leaders.

It is expected that the PHR programmes identified so far will take at least three years to complete though this may take as long as five years to include time to build up in-house facilitation expertise and to allow for cyclic studies being conducted in parallel. It is estimated that as many as 45 PHR leaders may be required to deliver this 'first-time' programme though this is likely to fall to around 25 to 30 to support a cyclic review programme based on a five-year cycle. It is expected that available leaders will leave the pool and replacements will be required, though this allows for process safety experience to be refreshed and moved elsewhere in the business furthering our aims to improve understanding of this subject.

## CONCLUSIONS

The particularly critical elements of TSE's safety management system have been highlighted as being most important for the immediate improvement of process safety management, namely: hazard identification, management of change, risk management and asset management. These have influenced the decisions to begin a wide-ranging PHA programme. The concept of a single safety management system with distinct guidance for process safety and personal safety underpinning this is vital to direct an improvement programme in process safety.

As an important first step in implementing improved arrangements for PSM, it is essential that early buy-in to a PHA programme is achieved top-down throughout the organisation. Building on the PHA programmes already undertaken for Seveso II compliance across the company, TSE embarked upon this in 2008, recognizing that a structured and proportionate approach was needed that recognizes the hazardous nature of the industry and is based on the severity of potential process-related hazards.

The successful application and adaptation of ABB's PHR methodology to its Seveso II and other facilities made it the methodology of choice for TSE on its HHFs. Centred on PHR, TSE's staged approach focuses on the initial identification of the HHFs within its operations, followed by a prioritised PHR programme based on the levels of dangerous substances and stored energy both across HHFs and also within the HHIs constituting each HHF. Given the nature of the operations within an iron and steel manufacturer like TSE, dangerous substances include not just those listed within the Seveso II Directive [European Council 1999 and 2003] but also molten metal, molten slag and high voltage electricity.

Equipping the organisation to undertake an effective roll-out and consistent execution of TSE's PHA programme required the selection/development of personnel who are both knowledgeable of pertinent aspects of process safety as well as appropriately experienced in how process safety is typically managed in a plant operating environment. A structured programme of competency development is being pursued based on the ABB model and founded on the acquisition of the required knowledge as well as PHR leadership skills arising from coaching/mentoring during PHR studies.

## REFERENCES

- Ormond A. L. and de Klerk M. Implementing Improvements in Process Safety in Corus. Hazards XXI Symposium, 2009.
- European Council Directive 96/82/EC. Extended by Directive 2003/105/EC.
- Turney R. D. Hazard Studies for Safety, Health and Environmental Protection, European Conference on Safety and Loss Prevention in the Oil, Gas and Process Industries, London, 1991.
- Ellis G. R. Action against accident hazards. *Hydrocarbon Engineering*, March 2005.
- Ormond A. L. HAZOP Studies and their Limitations. *The Chemical Engineer*, April 1995.
- Hopkins A. Failure to Learn, the BP Texas City Refinery disaster, 2009.
- Heinrich H. W. Industrial accident prevention: A scientific approach (4th ed.), 1959.
- Bird F. E. Management guide to loss control, 1974.