**Best Practices: Ideas and Proposals for the Natural Gas Industry Submission Form**

**Title:** PETRONAS Gas Berhad’s Total Pipeline Integrity Management System  
**Author:** Mohd Nazmi bin Mohd Ali Napiah  
**E-mail:** nazmi@petronas.com.my  
**Telephone:** 6 013 3888 411

**Description:**

An effective management system is vital for a company to manage its assets and resources to deliver business’ objectives to the board, staffs, stakeholders, investors and public. In the case of PETRONAS Gas Berhad (PGB), the company has been accredited with ISO 9001:2000 Quality Management System back in 1995. Since the accreditation, PGB has maintained and continuously improves its management system to remain relevant and current for it to deliver the business’ objectives.

In PGB, the management system consists of high, middle and working levels documents to standardise business practices throughout the organisation and eliminate any discrepancy. On top of that, the management also ensures system tools are available to assist the management and staffs to perform and carry out business activities. As depicted in Figure 1, PGB utilises a ‘pyramid’ concept in setting up its document management system.

![Figure 1 – Concept of Management System practiced in PGB](image)
At the highest level, there are specific manuals that explain the overall process of PGB’s business and how PGB manages its business to meet stakeholders’, regulator’s and public’s interests. Note that PGB puts the utmost importance to health, safety and environmental management by having a dedicated manual for those business elements. The Business Operating Manual (BOM) and Health, Safety, Environmental Management System (HSEMS) Manual are used by all divisions and departments within PGB as the reference documents to establish manuals, procedures and work instructions, that suits their own business processes.

PGB has established its Operating System Manual (OSM) and Reliability and Integrity Management System (RIMS) Manual as ‘mother’ documents to manage the operation, maintenance and integrity of its gas transmission system. The two manuals are supported by specific procedures and work instructions that guide PGB’s staffs in executing the day-to-day business processes and activities. The documents described above are stored as a controlled copy in an electronic version in a document management system called e-BOS i.e. electronic Business Operations System. The documents can be amended, reviewed and approved electronically without any hardcopy or manual intervention. This ensures prudent and effective cost management in terms of minimizing paper intervention and time consumption for approving authority to approve the documents accordingly.

Apart from e-BOS, there are several other computerised softwares that PGB’s management and staffs utilises on daily basis to assist them in executing their jobs. These critical softwares are, among others:

1. The Business Performance Tracking System (BPTS) that enables the management to track and view the company’s, division’s and department’s performances in terms of the Key Performance Indicators.
2. The Electronic Corrective and Preventive Action Management System (e-CPAMS) enables management and staffs to upload and view lessons learnt and brief report following investigation on accident and/or operational incident. It also has the capability to track and update on follow-up actions following any audit exercise i.e. system integrity audit, HSE audit, finance audit.
3. The Electronic Management of Change (e-MOC) enables PGB’s management to review, endorse and track approved changes i.e. change-of-design, upgrading, process changes onto the pipeline system.
4. The Pipeline Risk and Integrity Management System (PRIMS) assists PGB’ staffs in managing the integrity of the pipeline system.

At the management level, there are key management committees that strategise, drive and monitor PGB’s business. Apart from the common committees, PGB also establishes a specific committee to monitor and drive key reliability and integrity initiatives in the division. The establishment of the Reliability and Integrity Management Steering Committee ensures PGB in sustaining and delivering superior business results operationally and financially.

**PIPELINE INTEGRITY MANAGEMENT FRAMEWORK**

As PGB matures throughout its operating years while delivering superior business results, PGB is also looking into areas for improvement in relation to the overall management process of its
pipeline system integrity. Having come across American standards for managing pipeline system integrity i.e. ASME B31.8S and API 1160, PGB adopts and streamlines its management system according to the principal of the standards. Figure 2 shows elements within the Pipeline Integrity Management Framework. The framework consists of five main elements:

i. Integrity Management
ii. Performance Measurement
iii. Management of Change
iv. Communications Program
v. Quality Control System

![Pipeline Integrity Management Framework](image)

Figure 2 – Elements within the Pipeline Integrity Management Framework

Each element plays its own important role in the overall pipeline integrity management system. The elements are not totally new since existing management system also addresses in one way or the other the above five elements.

INTEGRITY MANAGEMENT

The element of integrity management solely addresses on how the assets i.e. the pipeline system need to be managed in a prudent and effective manner. It is a process by itself as depicted in Figure 3.
The process starts with gathering pipeline system information and data. Information from basic pipeline data, construction, testing, incident history, inspection, maintenance and repair are among key information that is needed. It is important that the information and data are verified by a team of operations, reliability, engineering and safety personnel so that the data remains updated and current. The information and data is stored in a ‘live’ electronic database for easy access and amendment in case of any changes. PGB utilises the PRIMS software to store the pipeline information and data.

With the above information and data, a risk assessment is performed for a particular pipeline section. Prior to that, typical pipeline threats are identified and they are as follows:

i. External and internal corrosions
ii. Stress corrosion cracking (SCC)
iii. Third party intrusion
iv. Incompetent operator
v. Geological i.e. flooding, soil erosion, soil settlement etc.

Among methodologies that are currently used by pipeline operators are (i) qualitative risk assessment, (ii) semi-quantitative risk assessment and (iii) quantitative risk assessment. PGB chooses the semi-quantitative method since it is blends of qualitative and quantitative and it is proven effective thus far. The risks of pipeline failure due to the above threats need to be calculated and for further action i.e. integrity assessment need to be conducted to ascertain the extent of the threats that could damage the pipeline.
There are several methods to ascertain integrity of a pipeline i.e. (i) in-line inspection, (ii) direct assessment, (iii) hydrostatic testing, and (iv) any other proven methods or technology. PGB uses methods (i) and (ii) for its piggable and un-piggable pipelines respectively. Further to the in-line inspection and/or direct assessment and to assess the pipeline’s defects, PGB utilises current methods prescribe by code and standard and best industry practices. Method prescribes by RSTRENG, detailed RSTRENG, Pipeline Defect Assessment Manual (PDAM), ASME B31.8S and API 1160 is used to assess pipeline defects appropriately and to determine the appropriate action to repair the defects. On top of that, PGB also determines the re-inspection interval using deterministic method prescribes by ASME B31.8S and API 1160 accordingly.

The whole process is repeated should any information and data is known to be changed from the existing ‘current’ ones. As mentioned in the earlier section, an integrated software tool i.e. PRIMS is used by appropriate staffs to assist them in executing the integrity management processes.

**PERFORMANCE MEASUREMENT**

Every organisation has some sort of performance measurement system and we practice performance measurement system that helps all staffs from management to technician levels to realise the company’s objectives. The performance measurement is cascaded down from top management to the working level using leading and lagging performance indicators. By having such performance measurement system, all staffs will have the spirit of togetherness in contributing to the overall division’s performance. Figure 4 shows how key performance indicators are cascaded down from top management to the working level.
The management usually holds the lagging KPIs i.e. results based and the working level i.e. engineers, technicians and operators usually hold the leading KPIs i.e. efforts based. The main principle in having the said performance measurement system is to translate the company into the division objectives, from division into departmental objectives, and from departmental into individual objectives. Another principle is having clear linkage from company to individual KPIs so that individual staff is fully aware that his/her efforts are important and directly affects the department’s, division’s and company’s achievements.

The platform that PGB uses to manage staffs’ performances is called Individual Performance Contract or IPC. The IPC contains two categories i.e. (i) performance planning, and (ii) performance review. The elements of (i) are the key objectives, performance standards and performance indicators, and for (ii) are the results and performance rating. The staffs’ IPCs are managed through an electronic system called Performance Planning and Appraisal (PPA). It is of the individual staff’s prerogative to plan and review his/her IPC with his/her own superior at least three times a year i.e. one for planning and two for mid-year and year-end review sessions. By having such system and the BPTS (as explained in the earlier section), divisions’, department’s and staffs’ performance are effectively measured and monitored. Any hiccups
and/or obstructions in executing individual objectives/tasks can be addressed and resolved in an efficient manner.

MANAGEMENT OF CHANGE (MOC)

MOC is one of the vital elements in PGB’s pipeline integrity management system. The main principle of MOC is changes need to be evaluated to ascertain its impact to safety of personnel and public, environment, current operations and maintenance practices and also financial impact to the organisation. Specific procedures to manage the overall process of MOC are established so that management and staffs are guided in executing the MOC process. The MOC procedures are developed based on the principles of Process Safety Management (PSM). As explained earlier, in PGB, MOC is managed through an electronic MOC system. Generally, the e-MOC system has the capabilities as follows:

i. Registration of MOC by any staff. Staff shall provide the proposed changes and reason/s that affecting the changes.
ii. Evaluation of impacts (as described above)
iii. Review by MOC committee
iv. Endorsement/approval of MOC by an approving authority
v. Monitoring of progress of MOC by a focal person

COMMUNICATIONS OF INTEGRITY RELATED MATTERS

Our organisation believes in effective communication and we embedded communication as one of the integral elements of the management system. PGB implements communication programmes with regulatory and local authorities, staffs and the public. These three groups of stakeholder need to be informed on company’s performance, the pipeline inspection and repair plans, incidents and lessons learnt as well as changes to the pipeline system accordingly. Through these communication programmes, the stakeholders will appreciate of what pipeline integrity is all about and cooperation and commitment from each stakeholder group can easily be sought for. Figure 5 shows the key elements within the communication program.

Figure 5 – Key elements within PGB’s communication program i.e. affected parties, the related topics/areas, the frequency, and the media of communication
QUALITY CONTROL

The final element in the Pipeline Integrity Management framework is Quality Control. To ensure the management system is effectively implemented and maintained, PGB conducts internal audit on yearly basis and third party audit on a three-yearly basis. The internal audit is carried out by cross divisional and departmental teams and at the end of the audit session, a report with non-conformances and observations for improvement is issued out. The respective department will take necessary actions to close the non-conformance and observation for improvement. As for the third party audit, the Malaysian certified ISO body called SIRIM normally comes and performs the system effectiveness audit. PGB has been carrying the internal and third party audit for years now i.e. since 1995, and each year we see improvement mostly on the number of non-conformances. It really shows that the management system works effectively and our staffs are continuously learning and improving themselves towards achieving the desired company’s and division’s objectives.

![Figure 6 – Simplified process of quality control i.e. audits](image)

EMERGENCY RESPONSE MANAGEMENT

The total pipeline integrity management is not complete without an effective emergency response management system, and for PGB, we practices an integrated emergency response system that comprises three elements:

i. Emergency response and incident command system or GERICS that spells out the level of emergency and the type of response that associated with each level of emergency.

ii. Business Continuity Plan or BCP is a high level document where it provides guidelines to deal with failure of business processes, be it core business aspects as well as information technology.

iii. Pipeline Repair and Rehabilitation Procedure is a document that provides guidelines to perform repairs on pipeline depending on the types of pipeline defects and failures i.e. leak and/or rupture.

PGB also conducts annual emergency response exercises at regional and national level to prepare the authorities, support services, operation personnel, customers and public with pipeline emergency response.
Areas:

Safety, reliability and organizational efficiency.

Results:

<table>
<thead>
<tr>
<th>No.</th>
<th>Integrity Action Items</th>
<th>Pre-2002 PIM Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Risk Assessment Method</td>
<td>Qualitative Risk Assessment</td>
</tr>
<tr>
<td>2</td>
<td>ILI Policy</td>
<td>Time-based i.e. 5 to 7 years</td>
</tr>
<tr>
<td>3</td>
<td>Corrosion Assessment Method</td>
<td>ASME B31G (ERF)</td>
</tr>
<tr>
<td>4</td>
<td>3rd Party Damage Prevention</td>
<td>Surveillance and Communications with Public and Authorities</td>
</tr>
<tr>
<td>5</td>
<td>Corrosion Prevention</td>
<td>Internal – Corrosion Inhibition and Pigging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External – CIPS, DCVG, Above ground inspection</td>
</tr>
<tr>
<td>6</td>
<td>Leak Detection</td>
<td>SCADA and surveillance</td>
</tr>
<tr>
<td>7</td>
<td>Repair Method</td>
<td>Pipe replacement, leak clamp, clock spring, epoxy sleeve, coating repair</td>
</tr>
<tr>
<td>8</td>
<td>Integrity Planning</td>
<td>ILI – time-based</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repair – as and when required</td>
</tr>
<tr>
<td>9</td>
<td>Failure History</td>
<td>3 leaks</td>
</tr>
</tbody>
</table>

Table 1 – PGB’s integrity management practices and failure history prior to implementation of PRIMS

<table>
<thead>
<tr>
<th>No.</th>
<th>Integrity Action Items</th>
<th>Post 2002 PIM Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Risk Assessment Method</td>
<td>Semi-Quantitative Risk Assessment</td>
</tr>
<tr>
<td>2</td>
<td>ILI Policy</td>
<td>Risk-based approach</td>
</tr>
<tr>
<td>3</td>
<td>Corrosion Assessment Method</td>
<td>RSTRENG, Rupture Pressure Ratio (RPR)</td>
</tr>
<tr>
<td>4</td>
<td>3rd Party Damage Prevention</td>
<td>Surveillance, Communications with Public and Authorities, Brochures and Pamphlets</td>
</tr>
<tr>
<td>5</td>
<td>Corrosion Prevention</td>
<td>Internal – Corrosion Inhibition and Pigging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External – CIPS, DCVG, Above ground inspection</td>
</tr>
<tr>
<td>6</td>
<td>Leak Detection</td>
<td>SCADA and surveillance</td>
</tr>
<tr>
<td></td>
<td>Repair Method</td>
<td>Pipe replacement, leak clamp, clock spring, epoxy sleeve, coating repair, furmanite composite</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Integrity Planning</td>
<td>ILI – risk-based and structured schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repair – corrosion growth study &amp; structured repair and verification schedule</td>
</tr>
<tr>
<td>9</td>
<td>Failure History</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 2 – Improvement can be seen from implementation of PRIMS i.e. no leak, ILI and integrity planning are risk-based etc.

Figure 7 – Pipeline reliability is at its highest i.e. nearly 100%
CONCLUSION

The success of the total pipeline integrity management system can be seen from the pipeline reliability rating of PGB-TOD’s pipeline system of which the figure achieved is nearly 100% i.e. 99.97% (please refer to Figure 7). On top of that, reduction in pipeline inspection and maintenance is also realised from the implementation of the total pipeline integrity management system (please refer to Figure 8).