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Asset Integrity Management System (AIMS) for the Reduction of Industrial Risks

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An Asset Integrity Management System is a necessary component of a well-functioning company. Arthur D. Little (ADL) proposes a 5-step approach towards building a robust and reliable system, that may help in better controlling risks resulting from all conditions and situations that may affect the integrity of assets during all life-cycle, such as ageing of assets, process variables modifications, management of different products, etc. The solid management system thus developed produces tangible results from which the whole company culture may reap benefits.

1. The need of an Asset Integrity Management System

1.1 Definition of assets

An asset is “an item, thing or entity that has potential or actual value to an organization. The value will vary between different organizations and their stakeholders, and can be tangible or intangible, financial or non-financial” (ISO 55000:2014).
Assets span many categories, ranging from infrastructures (e.g. highways, viaducts, etc.), to fluid transport networks (e.g. drinking water, fuel oil, etc.), to industrial plants (including both static and rotating equipment) and to local and national transportation networks (e.g. electrical grid).
The asset life is the period beginning with the conception and the initial stages of the asset design and ending with the decommissioning of the asset itself. Therefore, over its life, an asset can provide value, which may change over time, to one or more organizations.

1.2 Asset Integrity Management Systems

An Asset Integrity Management System (for short AIMS) includes several activities such as planning, control and monitoring activities, to exploit opportunities and to reduce risks.
The goal is to make sure that a system is in place to maintain asset integrity when needed, throughout the entire life cycle. Control measures include personnel, physical resources, procedures, process control systems and emergency plans dedicated to this task (NOPSEMA, 2012).
Asset Integrity processes are fundamental in reducing company risks: developed in industries with reduced or volatile margins (such as the refining and petrochemical industries), they should be now implemented anywhere a correct management is quintessential for company reputation, business continuity and efficiency or in all cases where the ageing of equipment can become a critical issue.
Typical examples are aqueducts, characterised by old assets and complex ramifications: waste of water and large releases (leading not only to economic impacts but also to reputational damages) are risks that call for the implementation of Asset Integrity methodologies.
Therefore, the main benefits obtained by the implementation of an AIMS are to:

- reduce the probability of catastrophic events;
- limit the exposure to risk, in terms of health, safety, environment, reputation and business continuity;
- help the Companies’ turnaround from “maintenance after fault”, reacting to events, to preventive and predictive maintenance schemes that proactively prevent faults;

The challenge is to find a balance between the high operating performances required by assets, on one hand, and the costs of TIMS activities (short for Testing, Inspection, Maintenance and Substitution), on the other; the

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system should be flexible enough to follow market evolution, while maintaining high safety and environmental standards. International recommended practices (API 581, 2008) can help an organization develop an inspection plan based on the risk posed by each equipment. Others may prefer a more holistic approach and develop their own system.

2. Arthur D. Little's Methodology

2.1 Definition of operating areas

The first step towards building an Asset Integrity Management System is to define the operating areas that the system will focus on, i.e. the assets involved in TIMS activities.
Figure 1 shows how an Asset Management System relates to other management measures and levels. The System should fit within the company's safety process and Risk Management procedures and within other quality or reliability improvement programs. That is, the approach should be built on existing frameworks and developed from there onwards (CCPS, 2006).
The methodologies to be used at this stage, either qualitative or quantitative, depend on several factors related to the examined occupancy.
The choice of the asset typologies to be included should be based on applied or applicable standards and regulations, on the requirements of management systems or programmes (safety management systems, quality management systems, testing programmes, risk-based inspections) already in place, on established future development plans (new technologies or new production sites).
All these parameters should be analysed by the team within the company to make sure that the list is complete and no important element has been overlooked.

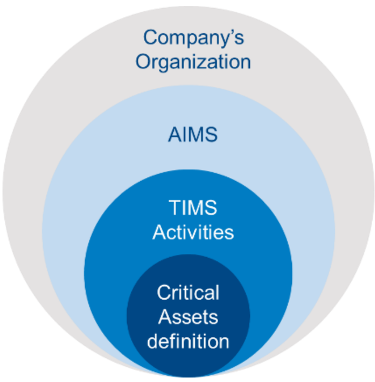

Figure 1: Relationship between key terms

2.2 Analysis of existing items

The second stage is a review of the Asset Integrity management practices that the company is already applying; a well-thought-out analysis can provide a solid reason towards building an AIMS that engages company resources, both materials and human.
A good review should have five fundamental chapters:

1. A presentation of existing formal or informal programmes, both at a general level and in-depth on each single unit; this chapter should also include Asset Integrity procedures and instructions;
2. A description of the asset types covered by existing programmes and the criteria that led to the operating area definition;
3. The definition of how the existing programmes face risks associated with assets' malfunction or loss of integrity; the review should also describe whether and how these risks have been appraised to prioritize asset TIMS activities;
4. The definition of roles, responsibilities and rules for the communication within the company (e.g. between Headquarters and single production units or, within each unit, among different departments or production lines). This chapter should also mention:
   - If any, discrepancies between allocated and necessary resources to complete TIMS activities;
   - Barriers hindering the exchange of information between operating levels and the management (and vice versa), both within HQ and in each operating unit;
   - Anomalies or gaps in the definition of reporting standards;
   - Company's expectations and goals for the implementation of an AIMS.

5. The description of the applied criteria and methodologies in monitoring the implementation and effectiveness of Asset integrity programmes, including changes—after tests or inspections. The review should be completed with an analysis of the improvement plan, to be discussed and verified by the management. The definition of the plan of improvement should account for international best practices and especially for each production unit's strengths to be maintained, strengthen even further and extended to the other units.
   An action plan should shortly follow, prioritising the actions according to costs, benefits, and time schedule criteria. Each action should provide an assessment of all the risks that could undermine its effectiveness and a list of countermeasures to contrast them.
   Once completed, the report will be a synthesis, at a company-wide level, of the "as-is" situation, capable of suggesting:
   - Strengths to leverage;
   - Quick wins to obtain results in a short time span;
   - Obstacles to remove whenever possible;
   - Performance misalignments among different production units.

The required information is collected via both a series of visits and meetings with a sample of personnel from the production units to be involved in the application of the AIMS. Visits and meetings will include focused interviews, field inspections and documentation collection.

2.3 Classification of Critical Assets

The next step is the identification of assets to be included in the TIMS activities, in other words a draw up of the list of critical assets (Figure 2).
This list should be the result of a systematic application of principles and rules defined and shared through collaboration with the people in charge of Asset Integrity and approved by Top Management.
The criteria should include elements from existing practices, typical criteria of the industry, standards or international best practices.
For example, in a refinery or in a petrochemical complex, four categories of critical assets could be identified:

- Safety Critical Elements (SCE), i.e. equipment's whose loss of integrity could lead to an uncontrolled release of hazardous fluids or energy;
- Operational Critical Elements (OCE), i.e. equipment's whose loss of integrity could impact the plant's availability and business continuity;
- Critical Preventive Barriers, i.e. systems (such as alarms, Safety Instrumented Functions (SIF) and pressure relief valves) which can reduce the frequency of a loss of integrity of an SCE or an OCE;
- Critical Mitigative Barriers, i.e. systems (such as containers, dikes, gas detectors, water spray, deluges, foam systems), which can reduce the consequences of a loss of integrity of an SCE or an OCE.

This stage is important for two main reasons: first, it ensures that TIMS activities are extended to all assets that truly need them; in addition, it is the first point of contact and sharing with the people in charge of planning and execution of TIMS activities.
It is also crucial to define the level of detail to get into; for example, the list could include single pieces of equipment or subsets comprising multiple machines, as different methodologies apply to different levels of detail. Risk assessment analysis, if executed in a systematic and detailed manner, can integrate the classification criteria. HazOp (Hazard and Operability), SIL (Safety Integrity Level) and FMEA (Failure Mode and Effect Analysis) analysis can all provide useful information for thee selection of critical assets.

Figure 2: Classification of Critical Assets

From these analyses, it may result that Critical Assets are associated with accidental scenarios caused by their loss of integrity, or are themselves preventive or protective barriers against an accidental scenario.

The effort and the resources for this third stage will depend on the level of detail and on the available information and studies. The result will be a report of all the Critical Assets for each production line, including supporting evidence to guarantee the transparency and traceability of the whole process.

2.4 Definition of TIMS Activities

The fourth step of the process is the definition of methodologies for the most suitable TIMS activities (Testing, Inspection, Maintenance and Substitution) for the list of Critical Assets.

Standards, guidelines and best practices are available and are combined with company personnel's knowledge and experience. It will be particularly important to: provide a clear definition of the department in charge, the timeframe and the technicalities of the activities to execute; plan support for communication and training; establish clear personnel roles, in order to avoid gaps or overlaps of responsibilities; define asset performance indicators.

Due to the fact that this kind of activity typically involves various departments of the Company's Organization (e.g. Operations, Risk Management, Procurement), two key issues must be tackled:

- create synergies between different departments, thus limiting the organizational silo mentality;
- effectively integrate AIMS into the existing Organization, thus avoiding that it is perceived as an additional formalism.

2.5 Development and Implementation of an AIMS

The fifth stage of the process is the development of the Asset Integrity Management System. The ultimate goal is to review and develop a ready-for-action AIMS, with a scale-up approach in the implementation process: first on a single production line or unit (a "pilot" unit), afterwards on the entire company network.

The AIMS should be in line with the company organisation and processes, to value the existing practices (Figure 3). It should be interfaced with other Management Systems or Programmes, such as Operation Management System, Risk Management System and HSE Management System.

Three activities are required for this stage:

1. The definition of an AIMS architecture, including:
   - Asset Integrity strategies to be followed;
   - Elements of the AI system (e.g. policies, strategies, goals, resources, roles and responsibilities);
   - Relations among several elements in the AIMS (e.g. definition of goals based on the policies);
   - The structural actions to ensure the AIMS' success.

   It is important to determine the stakeholders' expectations (headquarters and production unit personnel that are directly or indirectly involved in the TIMS activities). On-site visits will help reach two main goals: to maximise the value of existing documentation and practices, especially their application, and to integrate the new system with the existing programmes (HSE, Process Safety, etc.) to avoid overlaps and unnecessary paperwork. The final product of this activity is the Operating Manual to formalise the AIMS;
2. The communication and training to personnel: this is necessary to enable the development of a company-wide culture that can adopt the AIMS and the subsequent changes. All the communication and training activities will be part of the Management of Change programme and will be spread over time to fulfil the different requirements at different stages of the implementation. Two training sessions are suggested, first to top management and to operations unit management involved in the "pilot" phase, then to internal staff in charge of training, to favour awareness in the whole company.
3. The implementation of the AIMS, based on the application of the principles defined above and on a periodical supervision process. A typical PDCA (Plan – Do – Check – Act) management cycle, analogous to the existing systems, will be the basis of the review process. Such a structured approach helps identify competencies and gaps, underlining the need for training.

Figure 3: The AIMS Development Process and the main questions to ask during its development.

3. Output of the analysis

What are the tangible results of this process? There are three main outcomes of the analysis that can be used to build an AIMS:

1. A list of the identified Critical Assets, spanning all production units and in a pyramidal structure (Site, production unit, line, single asset) enabling managers to have a bird's eye view of the objects of TIMS activities to set up and possible imbalances in resource allocation;
2. A set of worksheets detailing the description and schedule of all TIMS activities on each asset. At a macro level, it helps top management to distribute resources properly; at a unit level, it is a roadmap of all TIMS activities, in order to follow the implementation status and to identify issues that need operating instructions or specific procedures;
3. A KPI system to evaluate the AIMS performances, both company-wide and of each unit and asset. KPIs (Key Performance Indicators) are presented to the client and discussed to develop a "tailored fit" model based on organizational size, average personnel's experience, type of assets, etc.
   Examples of KPIs for Asset Integrity Management are included in Table 1, both as lagging (easy to measure, but hard to influence, such as the number of accidents) and as leading (focus on implemented activities, such as testing, incident investigation, maintaining).

The three outcomes will merge into the AIMS set up, according to the Deming cycle (Plan – Do – Check – Act).

Table 1: Examples of KPIs for Asset Integrity Management System

AIMS element	*Example of lagging KPIs*	*Example of leading KPIs*
Mechanical Integrity	- Number of loss-of-containment incidents and near misses	- % of safety-critical plant / equipment that performs to specification when tested - % maintenance plan completed on time
Operating Procedures and Practices	- Number of operational errors due to incorrect/unclear procedures	- % of procedures reviewed and updated - % of operators who received training on procedures during the last year
Electro-instrumental Integrity	- Number of incidents linked to failure of instrumentation or alarms - Number of incidents due to electrical systems faults	- % of function tests of alarms/trips completed on schedule - % of electrical substations analysed by means predictive methods
Management of Change (MOC)	- Number of incidents linked to failure of MOC	- % plant changes suitably risk assessed and approved before installation - Average time taken to fully implement a recommendation once approved

Table 1: Examples of KPIs for Asset Integrity Management System

Plant design	- Number of incidents related with errors in plant design	- % safety-critical equipment/systems fully in compliance with current design code
Work Permit System (WPS)	- Number of incidents related with errors in WPS	- % WPs sampled which have identified all hazards and specified all suitable controls - % WPs sampled where all controls listed were fully in place at worksite

4. Conclusion

This paper has introduced the Arthur D. Little's framework for the design and implementation of an Asset Integrity Management System.

Even if Asset Integrity processes were firstly developed in industries with reduced or volatile margins (e.g. refining, petrochemical), nowadays other sectors (e.g. power generation and distribution, district heating, dams, water treatment, aqueducts, travel and transportation networks) can benefit from their effective implementation.

Indeed, a structured AIMS can help Companies in reducing their industrial risks, which could typically have huge impacts on Companies' reputation, business continuity and efficiency and in optimizing the management of ageing assets, an issue which is becoming more and more important in many old industrial complexes.

Several benefits of such framework have been described and assessed in this paper.

First of all, an effective AIMS turns out in a reduction of dangerous events that could affects safety, environment and business continuity: all of that is directly linked to Companies' reputation and to the constant effort spent to protect and improve it.

Secondly, the positive impact that the AIMS has on the Test, Inspection, Maintenance and Substitution activities, helping Companies in switching from a poor fault based maintenance to a preventive and predictive one. Several more benefits stem from this change in mentality are: more consistency in maintenance activities, which will be focused on assets that really require them, to save money and time over unplanned maintenance; an optimisation in the management of stock and spare parts; an improvement in the performances of external maintenance contractors, which will operate according to a clear TIMS activity plan.

Last but not least, the establishment of the proposed framework supports the Companies in successfully optimizing internal organizational processes (breaking down the common silo mentality) and in improving asset investments. Analysing, implementing and monitoring an AIMS are all parts of the broad sphere of "Risk Management", a practice that an increasing number of international standards push towards, being the ultimate goal of any company who aspires to protect its business.

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