CHAPTER 1

Introduction

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1.1 INTRODUCTION – FACILITY INTEGRITY MANAGEMENT

The oil, gas and petrochemical sectors spend billions of dollars every year to maintain facility integrity. If done well, facility integrity management can have a positive impact on a company’s profit and loss account, prolong the life of the facility and optimize the operating efficiency and effectiveness of processes and equipment. Conversely, if done poorly, it can reduce large blue chip companies to bankruptcy.

Facility integrity management is the means of ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and fit for purpose over the whole life cycle of the facility. It is a process that requires an optimized balance between resources and output; ensuring facility integrity management is well structured and managed is key to its success in terms of a well-run and managed facility and a good return on facility production output.
This book is about how the concepts within facility integrity management can improve the performance of a facility, making substantial improvements to the safety, operational effectiveness, and ultimately profit of an oil, gas and petrochemical production facility. It provides a detailed explanation of the key principles and processes with easily referenced material that has been tried and tested successfully in the field.

1.2 CHANGING INDUSTRIAL LANDSCAPE

Producing high-quality products at competitive prices is paramount to maintaining a successful business in today’s ever-evolving industrial landscape. Oil, gas and petrochemical operators are constantly challenged to ensure their facilities are safe and environmentally friendly and their production equipment is running smoothly and is available whenever required. In order to satisfy customers’ needs, operators are constantly looking for new, improved ways to ensure equipment and systems are available and operating as lean and efficiently as possible, and at the same time reducing cost.

Over the past few decades the approach to integrity management of petrochemical and oil and gas facilities has changed dramatically, perhaps more so than most other industrial markets. This change has come about through several key drivers in the industry. Probably the most fundamental driver has been the need to make a step change in the approach to process safety in response to a string of process facility disasters. This is followed by the fact that there are now many more operators in the market than in the past and in order to maintain profit margins, operators are required to be much leaner, lowering their overhead costs. Operators have also found that there has been an increasing demand for higher specification products, mainly to cope with the more stringent legislative requirements but also to meet the end user demands, such as technological advances in automotive and aviation products.

These changes have had a profound impact on oil, gas and petrochemical facility operators. This has led to an increase in the demand on processes and equipment to perform more complex processes longer and more efficiently, and also to come up with equipment and new product development, leading to new processes and equipment.

In the face of this torrent of change, facility managers are looking for new, more cost effective, ways to improve equipment reliability, maximize uptime, and optimize maintenance and operations efforts in order to reduce unscheduled downtime in their approach to operating and maintaining their facilities.
Many facility operators have responded by going back to first principles and rethinking the way their integrity and maintenance groups should operate. Facility integrity and reliability (FI&R), maintenance, and operations departments in the past have traditionally operated in silos – that is, operated as independent units, effectively disconnected from each other to a large extent. This has inadvertently put up barriers around the core integrity departments and ultimately disrupted the flow of information between the various interfaces within the facility, from the facility leadership team to the various stakeholders, having a negative impact on facility operations.

As a result of the numerous major oil, gas and petrochemical facility incidents that have caught the headlines over the years, operating companies are considering integrity and reliability as a standalone department that works alongside maintenance and operations departments with the primary goal of ensuring safe operation and optimum availability of facility processes and equipment. In order to illustrate this point, I draw upon a case study which occurred at the Humber Refinery in the UK on 16th April 2001, where there was a serious incident resulting in an explosion and fire at the Refinery Saturated Gas Plant; the incident was investigated by the UK Health and Safety Executive \[1.1\]. One of the key outcomes of the report was a reorganization of the Refinery Organization Structure with emphasis on the integrity department. This case study is explored in more detail, in order to draw out the key learning points, in Chapter 2.

A robust and well-implemented facility integrity management system is essential to ensure coordination between these departments in order to ensure all aspects relating to integrity of the facility have been considered and adequately addressed. The development and implementation of an effective integrity management system requires a concerted and dedicated effort across the facility organization.

1.3 THE ROLE OF FACILITY INTEGRITY

The fundamental role of facility integrity in the operation of oil, gas and petrochemical facilities is to:

1. Maximize the availability of the facility.
2. Provide integrity assurance for the facility.

The role of maintenance and integrity has never been more critical to the oil, gas and petrochemical industries. In addition to providing confidence and assurance to facility owners that operational risks can be identified and managed, the facility can now drive towards achieving operational
excellence by optimizing the performance and extending the life of equipment and systems.

Maintenance and integrity have a key role to play across all stages of the project life cycle, not just during the operating stage but also during the design stage where many of the critical process safeguards and availability of equipment and processes are established. We shall now consider each of the fundamental roles of maintenance and integrity in turn.

### 1.3.1 Ensure the Availability of all Facilities

Availability is a measure of facility **uptime** or, in other words, how often facility equipment and systems are alive and function as they were designed to. Ensuring the availability of the facility in today’s market is critical in order for business to be successful. Today’s global marketplace is fueled by an ever-increasing demand for oil and gas commodities to feed the growing global energy demand.

Since 1952, the *BP Statistical Review of World Energy* has provided objective global data on energy markets. This longevity and robust reporting helps put today’s picture into context to help us understand how the world around us is changing. The *BP Statistical Review of World Energy* for June 2014 presents the global demand for crude oil and natural gas, among other energy sectors.

The illustration in **Figure 1.1** shows the production and consumption by region over the last 25 years. In 1988 the world demand was approximately 65 million barrels per day, growing to over 90 million barrels per day in 2013. In 25 years global consumption has grown by nearly one and a half times.

Similarly, the trend for natural gas was approximately 1800 billion cubic meters per day in 1988 and has grown to nearly 3500 billion cubic meters per day in 2014, almost doubling in growth in 25 years.

Coupled with the natural growth rates of oil and gas commodities and derivatives, there has also been a demand on oil, gas and petrochemical operators to improve product specifications in order to meet the ever more stringent compliance requirements in line with global environmental standards.

A key driver of this change is through global emissions reduction initiatives. Emissions standards focus on regulating pollutants released by automobiles and emissions from industry, power plants and small equipment such as diesel generators. There are numerous emission standards that have all followed this theme, which has primarily grown out of the Kyoto protocol.
[1.2], including the US Environmental Protection Agency (EPA), Clean Air Act 1970, UK Health and Safety Executive, among many others.

In addition to product development through compliance-driven regulations, a number of new products have come into the mix in recent years. Most notable are alternatives to lead-based fuels for the automotive industry and synthetic fluids and advanced lubricant oils, which have been driven through technology-pull developments in the automotive industry.

The net result of all this change is that there is an ever-increasing demand for oil, gas and petrochemical commodities, constant requirements for improving product specifications, and new products. As a result oil, gas and petrochemical operators have been forced to embark on a journey to make step change approaches in their quest to remain competitive and compliant and develop new ways to increase productivity, maximize process equipment uptime, ensure world class safety standards and altogether reduce operations and maintenance cost.

The secondary effect is an increase in the number of and complexity of manufacturing processes that need to operate with a high degree of availability and maintenance.
Oil, gas and petrochemical operators have responded by taking a critical look at the way they approach integrity management, reliability and maintenance with the intention of radical change.

1.3.2 Safeguard the Integrity of all Facilities

Over the last 50 years or so there have been a number of major petrochemical, oil and gas disasters resulting in loss of life, severe environmental impacts and property damage, providing reasons for the public to be wary about oil, gas and petrochemical facilities.

There are many underlying root causes leading to an initiating event; however, in many cases, the approach to management of integrity has been identified as a major cause. A number of recent disasters bear strong evidence to this proclamation. A brief overview of two of the major oil, gas and petrochemical disasters that resulted in step change approaches to integrity management is given in the following sections.

1.3.2.1 The Piper Alpha Disaster

The world’s deadliest-ever offshore oil rig accident happened on July 6, 1988, killing 167 out of 228 men in 22 minutes.

A report following the disaster by Scottish Judge Lord Cullen concluded that the operator, Occidental Petroleum, had used inadequate maintenance and safety procedures, resulting in the largest manmade catastrophe. A series of grave mistakes was made in design and operation that ultimately led up to the incident. A key contributor was the modifications completed to the initial design, including a new gas compression process which was located near the existing central control room, perceived to be one of the most dangerous production areas on the platform. There clearly was little effort to consider and safeguard against the associated risk, in terms of management of change.

During operation, the operator also decided to keep the platform operational and producing oil and gas as it made a series of major construction, maintenance and upgrade changes, which increased the risk factor.

There was a distinct lack of communication during shift changeover, which meant that the rig workers were unaware that they should not use certain piping, which was under maintenance at the time. This piping had been temporarily sealed with no safety valve. Ultimately, gas leaked out at high pressure, ignited and exploded. The protective firewalls failed because they were designed to withstand fire and not explosions, as fundamentally the original design intent of the platform was for oil production and not gas production, which is potentially far more hazardous.
Lord Cullen’s report included 106 recommendations to the industry, all of which were accepted. The outcome of this disaster has had a profound effect on the oil and gas industry and sparked a complete overhaul of the governing safety regulations, which included Offshore Installations (Safety Case) Regulations 1992. This meant that all operators were now required to present a safety case to the Health and Safety Executive (HSE) agency for oil and gas production facilities [1.3].

1.3.2.2 The Flixborough Disaster

On June 1, 1974 a large explosion at the Nypro Chemical facility at Flixborough in the UK resulted in 28 fatalities and severe property damage to the facility and surrounding area. The devastation was vast; fires started on-site after the explosion were still burning some 10 days later with around 1,000 buildings within a mile radius of the site in Flixborough and neighboring villages damaged.

The Nypro Facility produced caprolactam from cyclohexanone, a highly flammable material, which was ultimately used in the manufacture of nylon.

Prior to the explosion, it was uncovered that a vertical crack in one of the reactors on the facility was leaking cyclohexane. The facility was subsequently shut down to investigate, which resulted in a serious problem identified with the reactor. A decision was therefore made to remove the problematic reactor from service and install bypass connecting pipework to connect the adjacent reactors in order to continue production.

During the late afternoon of June 1, 1974, the bypass system ruptured, which resulted in the escape of a large quantity of cyclohexane. The cyclohexane formed a flammable mixture and subsequently found a source of ignition; shortly after there was a massive vapor cloud explosion.

The formal report issued by the court of inquiry identified a number of failings. The report noted that the facility was “well designed and constructed” but the bypass system modification was implemented without a full assessment of the potential consequences. Only limited calculations were undertaken on the integrity of the bypass line. No calculations were undertaken for the dog-legged shaped line and no drawing of the proposed modification was produced. The bypass line had also not undergone thorough testing and analysis including a pressure test.

The report noted that there was a distinct lack in the capacity and competence of personnel on the facility, especially during the modification of the bypass line. It was noted that at the time of the disaster no professionally qualified engineers were in the works engineering department.
The control room was occupied by 18 staff, all of whom lost their lives as a result of the windows shattering and the collapse of the roof. The design of the layout, including the control room, was not done based on consideration of a major disaster happening instantaneously. Furthermore, the structural design of the control room did not allow for major hazard events.

The report highlighted a number of observations and lessons to be learned. Proper management of change needs to be employed during facility modifications, which should be designed, constructed, tested and maintained to the same standards as the original plant.

There was no hazard assessment or Hazard and Operability study (HAZOP) conducted during the modification to understand the implications of the change. The incident happened during start up, a particularly stressful environment where critical decisions were made. For example, there was a shortage of nitrogen for inerting. This would inhibit the venting of off-gas as a method of pressure control and/or reduction.

The disaster was met with public outcry and was criticized for the lack of change management and has been instrumental in a more detailed and systematic approach to process safety in the UK. The emphasis was on fast restart of the plant after the initial leak and not on the investigation of the new modification and of any implications of this modification on future production and safety [1.4].

1.3.2.3 The Effect on the Oil, Gas, and Petrochemical Industries

Many of the major oil, gas, and petrochemical incidents arose from the cumulative effect of a range of errors and vulnerabilities introduced throughout the life cycle of the facility through design, construction, operation and maintenance. In many cases, there is a considerable amount of fragmentation between the different facility departments, including operations and maintenance; in many circumstances these departments are outsourced, leading to further fragmentation.

Oil, gas and petrochemicals are hazardous substances and most of the equipment used in the facilities is there to contain and manage the hazards. Keeping oil, gas and petrochemical facilities available and in good working order is critical in order to eliminate loss of containment and ultimate disasters.

The two main causes of loss of containment are either failure of the facility equipment or human factors, and may be initiated through a number of mechanisms. Facility equipment failure (FEF) may include poor process design, incorrectly specified equipment, corrosion or erosion mechanisms,
overpressure or over temperature, stress or fatigue or vibration mechanisms, defective equipment and degraded or aged equipment. Personnel failure (PF) may include noncompliance with procedures, inadequate isolation during operation or maintenance, dropped objects or impact to equipment and incorrect installations.

The catastrophic Piper Alpha platform disaster in 1988 shocked the world and woke up the oil and gas industry. The Lord Cullen report concluded that there was far too little understanding of oil and gas operational hazards and management of their associated risks. The industry came to the realization that there is a need to develop a systematic and methodological way of assuring control over these hazards.

As a result of Lord Cullen’s report, the Offshore Installations Safety Case Regulations came into force in 1992. The law dictates that owners and operators of all fixed and mobile offshore installations in UK waters must provide a safety case to the HSE. The safety case must demonstrate that the company has facility integrity management systems in place. The systems must have identified risks and reduced them as much as is practically possible. The safety case must also have made provisions for safe evacuation and rescue. As of 1995, each safety case for all installations falling under these regulations had to be submitted and accepted by the HSE.

The Piper Alpha Disaster had a landmark effect on the oil and gas industry. The industry’s approach to the management of facility integrity radically changed. Oil and gas owners and operators conducted immediate and comprehensive assessments of their facilities and corresponding facility integrity management systems. Offshore operators reviewed their strategies and invested over a billion USD to address shortcomings in integrity management of their facilities. This was the nucleus for the change in culture, leading more towards integrity management and safe operations.

1.4 FACILITY INTEGRITY MANAGEMENT SYSTEMS

1.4.1 Does This Look Familiar…?

Before we move forward let us take a moment to consider what some of the day-to-day scenarios may look like in the absence of a facility integrity management system:

- Aging equipment at extended life and operating at maximum levels
- Gaps in management systems and fragmented reliability programs
- Acceptance of equipment and facility processes operating with substandard performance
• No or limited attention to management of knowledge of equipment and process data
• Unplanned shutdowns are common
• Silo mentality across the organization with no or limited interdepartmental cooperation or strategic direction
• Dashboards are prepared and issued on an ad hoc basis and information is not reliable
• Changes in facilities operation and modifications to equipment are not documented nor managed through a robust system

Effective management of facility integrity can bring about step change improvements on a facility. These improvements can be seen across the breadth of a facility, even areas that may traditionally not be realized and the benefit not fully understood. These may include improvements to production through equipment and systems optimization, minimizing unplanned shutdowns and associated lost profit opportunities, optimizing maintenance and inspections, workshop efficiency improvements, right sizing of the facility workforce, all resulting in cost savings.

Facility integrity also includes compliance with regulatory and company requirements being in place. In this desired state, we will find a very different picture. Some of the following scenarios are likely to be common:
• A facility operating with zero unplanned shutdowns and incidents
• An organizational culture that take a keen interest in identifying and resolving process upsets and equipment malperformance
• A competent, experienced and dedicated workforce
• Continuous improvement and optimization of facility process work flow
• A facility dashboard with proactive performance indication
• Synergy between the numerous facility working groups and teams
• Knowledge-based organization with a reliable historian of plant performance and operation data

The development of an effective system that can manage the integrity of a facility requires a structured and dedicated approach. A facility integrity management system does not exist in isolation. Successful implementation requires a unified approach across the facility organization with a common understanding of integrity management and the criticality of each employee’s role.

1.4.2 Facility Integrity “Excellence”?

We have discussed that the fundamental role of maintenance and integrity is to maximize facility availability and safeguard integrity assurance; now taking this one step further, let’s consider what needs to be done to achieve facility integrity “excellence.”
Striving to achieve excellence in facility integrity management would certainly result in the aim to maximize the availability of the facility in order to achieve target production. It would also aim to safeguard integrity assurance in order to eliminate integrity-related incidents. Excellence must also aim to maintain the facility in a fit-for-service condition with all equipment and systems functioning as per their original design intent.

Since it is all too common that many facilities are functioning beyond their original intended design life, facility integrity excellence should also consider the assessment of remnant life of equipment and systems with the intention of prolonging facility life.

Ensuring there is a practical consideration for cost is also a key attribute of a facility integrity management system. There are no blank checks and all operators are competing in the industry to make money. Each element within a facility integrity management system needs to consider value for money and minimize cost where appropriate.

Finally, there needs to be a continuous review and improvement cycle to ensure lessons are learned and processes can be optimized on an ongoing basis.

It is clear that in our quest towards achieving the goal of facility integrity excellence, there are a number of complex obstacles to overcome. Although we can never quite achieve excellence, we certainly can drive towards a facility integrity management system that ensures there are no incidents involving breakdowns or degradation of equipment or systems, that maintenance and operations are so well executed that there is minimum effort expended and that the facility availability is almost 100%.

1.4.3 Planning for Facility Integrity Management

Facility integrity management is a continuous assessment process and it should be applied across the life of the facility.

Good integrity performance comes about as a result of good quality design and construction, as well as good operations. It is critical therefore that integrity management activities be initiated at the earliest stage of the facility life cycle, at the conceptual design stage, and continued right through to detailed engineering, construction, commissioning and to the operations phase.

Planning for integrity management of a facility starts in the design phase of the facility life cycle. This process first involves the development of the facility strategic objectives. This is the facility senior management team strategic vision and includes objectives for production, product mix, safety, environment, equipment availability and maintainability strategies. For mature facilities this may include business growth strategies, such as extension of
process equipment and systems life, increasing the mean time between failure (MTBF) of equipment and extending time between shutdowns.

The planning process moves to defining the integrity organization to sufficiently support the operations, maintenance, and facilities integrity and reliability departments. This process details the numerous organization charts, competence requirements and future training requirements.

During the design phase, the process of planning for integrity management is shown in Figure 1.2.

The next step involves assessment of the risks and evaluation of major hazards. This process details the safe operating parameters (integrity limits) for equipment and also defines the criticality of the facility equipment. This is important so that resources can be assigned sufficiently and availability targets met for facility equipment and systems. A common rule of thumb in the industry is that most of the risk is carried by only a small percentage of equipment and systems. This is a concept illustrated graphically in Figure 1.3. The criticality concept and relationship to the Facility Integrity Excellence Model (FIEM)© shall be discussed in detail in Chapter 4.

It is important that hazards are identified as well as their consequences. This can then be used to make sure controls are in place from prevention to containment and recovery. An effective tool used in the industry is called the bow-tie model. This tool introduces layers of protection in order to manage hazards and their consequences. It is used throughout the oil, gas and petrochemical industries for the management of facility process hazards. Figure 1.4 shows a high-level overview of the bow-tie model [1.5].

Bow-ties were first used in the 1970s by Imperial Chemical Industries (ICI) in the UK. Since then, the bow-tie model has been used extensively throughout the oil, gas and petrochemical industries to manage their hazards and consequences.

We will revisit this useful tool during Chapter 6, where we will cover risk assessment in facilities operations.

Once hazards are assessed and risk assessments are carried out, detailed plans are developed and implemented to manage risk. These include specific plans for maintenance, operations, facility integrity and reliability and management of change.

The final step of our planning process for integrity management is to review and learn from our performance. The continuous review cycle includes learning from incidents and equipment failures. We also need to develop a set of proactive key performance indicators (KPIs) in order to develop baseline data, so that we have a basis for improving our performance.
Figure 1.2 Planning for integrity management.
Facility Integrity Management

1.5 INTRODUCTION TO FACILITY INTEGRITY EXCELLENCE MODEL

In its simplest form, a facility integrity management system can be made up of three essential elements. These include a *technical element*, associated with maintenance, facility integrity and reliability; a *personnel element*, which considers the driving force behind integrity management systems, namely the facility organization, its people; and a *support processes element*, which includes a number of core processes and procedures required in order to ensure that the technical and personnel elements are working together with a common goal. Integrity cannot be achieved without these three elements in place.
1.5.1 Holistic Viewpoint

The Facility Integrity Excellence Model recognizes that the successful Integrity programs of this world are founded on the basis that the individual component parts inherently depend on each other in order to be successful and function as a whole. This is because there are significant synergies to be achieved in the numerous overlapping complex processes. These processes all have natural interdependencies and ensuring that these dependencies are integrated and information flow is effective and unconstrained is essential in unlocking the additional value.

This notion is often overlooked or not managed properly in the industry and this can result in high operation and maintenance costs, unreliable equipment and, in some cases, substandard HSE performance. Furthermore, it is noted that, with one of these processes lacking, the whole process of integrity management is vulnerable and there is a higher risk of failure.

The concepts that make up the Facility Integrity Excellence Model are developed with a holistic picture in mind. This is important because integrity management process interdependencies can then be easily identified and properly managed.

The FIEM knits together all of the core and support elements of facility integrity management in order to provide the reader with a comprehensive guide for integrity, maintenance and operations management of petrochemical facilities.

1.5.2 Risk-Centered Culture, the Heart of Facility Integrity Management

As with all successful facility integrity management systems, the heart of the FIEM is its people.

In order to be successful, the integrity organization must have the right beliefs, the right mindset and way of working, or culture. Effective integrity management of a high hazard facility requires integrity processes to be embedded at all levels of the organization, top–down and bottom–up, from the policy to the strategy and finally to the work procedures and standards that operate within the company.

“A change sticks when it seeps into the bloodstream of the corporate body” [1.6]. Until new behaviors are rooted into social norms and shared values, they are subject to degradation as soon as the pressure for the change is removed. It is the culture of the organization that is the target for change in order for the implementation of the excellence model to be effective.
Because this is so important, we shall explore in detail how to go about implementation of major change, such as a new integrity management system, in Chapter 11.

Risk-centered culture (RCC) is the term given to the heart of the excellence model, which represents the organizational culture. Culture is a key component of the concept of RCC, which considers the way the facility organization’s employees behave. Organizational discipline underpins all effective risk management systems. When the major oil and gas incidents of recent times are analyzed, such as Piper Alpha, it is clear that poor organizational discipline has led to inadequate risk management resulting in a major incident that could have easily been prevented. Risk-centered culture will be presented in detail in Chapter 3.

1.5.3 Facility Integrity Excellence Model Representation

The FIEM is represented in Figure 1.5. We can see that in the center of the model we find risk-centered culture. The intention here is to highlight the importance of the organizational culture being in place and properly functioning in order for a facility integrity management system to be effective.

1.5.4 The Three Essential Elements of Facility Integrity Management

We have already discussed that facility integrity management needs to consider three essential elements which are fundamental to effective integrity management. Within the FIEM these are: facility, which addresses the technical aspects; personnel, which focuses on the resourcing and competence of the integrity organization; and supporting processes, which address the key processes required to support the integrity management system.

The three essential elements are represented as segments arranged around RCC (in the center of the model) in Figure 1.5. This symbolizes their dependency on ensuring the foundation is in place – a healthy organizational culture. These essential elements or segments are further detailed in a series of work flows which will be discussed in the following chapters.

To outline the essential elements, we will first look at the technical element. ‘The Facility’ segment of the excellence model is intended to provide a detailed understanding of the key processes that ensure the safe and effective operation and maintenance of the facility from a technical standpoint. This segment of the excellence model comprises three aspects. First is
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There are a number of fundamental processes that support facility integrity; these are represented in the model under the second segment, ‘Supporting Processes’. The first process within the supporting process segment is management of knowledge, which focuses on capturing and learning from performance maintenance, which is concerned with quickly correcting failures, minimizing equipment and systems downtime, while balancing the associated resources and cost. Second is facility integrity and reliability, which applies risk-based methods to ensure the integrity and reliability of critical equipment and safety systems, describing the ability of equipment or systems to function under stated conditions for a specified period of time. It also focuses on ensuring that equipment and systems are properly designed, installed in accordance with specifications, and remain fit for use until retired. The third aspect is operations, which is concerned with ensuring the facility is operating on demand, efficiently and within its integrity limits.

Figure 1.5 The facility integrity excellence model.
data from each of the facility segment processes and ensuring this is put to good use. For example, a minor reoccurring equipment failure over time will consume a considerable amount of resources. If failure data in this scenario is collected and analyzed, the root cause of the equipment failure may be identified and resolved, which eliminates the reoccurring failure and wasted ongoing resource allocation. Management of knowledge is very important but also making sure that relevant information is collected and that it is used correctly is equally as important. The Supporting Processes segment also includes processes for incident reporting, quality assurance and auditing, and management of change. These processes are detailed in Chapter 6.

‘Personnel’ segment of the model underpins the Facility and Supporting Processes segments in that it drives towards ensuring an appropriately resourced and competent organization is in place to support the facility. In the absence of a competent integrity organization, all efforts to deliver facility integrity will be ineffective.

1.5.5 “What Gets Measured Gets Done”

Continuous improvement is a fundamental quality of the FIEM. It is absolutely essential to measure the performance of the facility in order to address shortcomings in equipment and systems performance.

In addition it is important to measure performance of the integrity processes, not just the performance of facility equipment and systems. This is in order to enable the improvement of the integrity management system as a whole. FIEM assigns key performance indicators to its processes in order to manage and improve their performance.

It is important that a comprehensive mix of KPI data is measured and presented in an easy-to-understand dashboard in order to “tell the full story” rather than an incomplete version. This will include a balance of information that relates to historic performance (reactive KPIs) and information that can give indication of future performance (proactive KPIs).

FIEM also takes into account hierarchy of reporting, which aims to present information as it is required at the different management levels in the integrity organization. For example, at senior management level, information about total recordable incident rate (TRIR) relating to safety performance and profit and loss will be required. Within the maintenance department typical information that may be required to improve performance will be about equipment performance, such as mean time between failure (MTBF). The Continuous Improvement element of the FIEM will be presented in detail in Chapter 9.
1.6 DESIGN CONSIDERATIONS FOR THIS BOOK

This book has been designed and structured in a unique way, for ease of understanding and application of the concepts that describe the Facility Integrity Excellence Model, which applies to both existing and new facilities. Figure 1.6 shows a flow chart with the core integrity work flow process identified. Each of the core work process is described in detail in the chapters highlighted, which makes up the structure of the book.

The following premises were used during the development of this book to ensure this principle is adopted:

1. Holistic approach to facility integrity management with workflow processes detailing the key concepts and how they function together as a system.
2. Solid foundation of knowledge and information.
3. Practical application of the key concepts, in terms of the author’s viewpoint rather than a theoretical account, which is often difficult to digest and apply to real production facility scenarios.
4. Quick and easy to read and page through to relevant theory and applications.
5. Aimed at a wide-ranging audience including graduates, young engineers and managers.

This book also considers the softer side of the organization and presents effective techniques for the implementation of a new facility integrity management system in existing facility organizations. Organizational change management is a difficult process to get right especially due to the fact that effective integrity management has many stakeholders throughout the organization. FIEM presents effective tried and tested techniques for implementing changes of this nature in large complex organizations. There are real financial gains to be realized through implementation of the concepts presented in this book.

1.7 CHAPTER-BY-CHAPTER SYNOPSIS

1. **Introduction.** Chapter 1 sets the scene for facility integrity management. It discusses how, more often than not, there are gaps in the industry’s approach to integrity management. It introduces the concept of an integrity excellence model that can address some of the shortcomings, focus on improving facility performance and save on costs.

2. **Facility Integrity Excellence Model.** Chapter 2 explores the Facility Integrity Excellence Model in detail, explaining how each of the elements of the model work and fit together and the resulting synergies can be realized. The chapter presents the case for integrity management by reviewing a case study that explains what can happen when integrity goes wrong and how integrity management systems are of paramount importance in the effective day-to-day operation of an oil, gas or petrochemical facility.

3. **Risk-Centered Culture (RCC).** The heart of the facility integrity excellence model is its people. The concept of risk-centered culture is presented in Chapter 3, which describes the collective beliefs of the integrity organization. RCC ensures that these beliefs are aligned to achieving integrity excellence and are engrained into the organization from the shop floor level to the top management.
4. Facility Integrity and Reliability. The key concepts of facility integrity and reliability (FI&R) are presented in detail in Chapter 4. FI&R management is the means of ensuring that the people, systems, processes and resources, which deliver integrity, are in place, in use and fit for purpose over the whole life cycle of the facility. The chapter explains how FI&R can influence the profit and loss of the facility. The chapter explores failure of equipment and systems from first principles, and presents sound root cause analysis techniques that have been tried and tested in the field. The key concept of facilities equipment criticality is presented and the chapter shows how many of the excellence model concepts are integrated within this concept. Finally the chapter explores the shift from a reactive to a proactive facility management strategy.

5. Maintenance Management. This chapter introduces a number of common failures in facilities maintenance management that are well known throughout the industry and discusses how these failings can be overcome through the concepts introduced in the excellence model. The notion of reactive versus proactive maintenance is explored and the key maintenance strategies and maintenance management principles are presented by introducing the excellence model maintenance element of the facilities segment.

6. Integrity Operations Management. Integrity operations management involves monitoring operations performance and responding to different scenarios that come about. It defines the concept of operational variances which occur when the facility is not operating as planned. It also introduces integrity limits in order to control performance and ensures safe operation. The chapter then explores unit monitoring principles and details the techniques for assessment of equipment condition, early warning of incipient equipment failures and equipment degradation. It proposes tried and tested methods for equipment surveillance, reporting and prompt response in order to minimize equipment outage.

7. Supporting Processes. There are a number of supporting processes that are required in order to ensure facility integrity management is effective and sustained. These supporting processes are detailed in Chapter 7 and include management of knowledge, management of change, incident investigation and management reviews.

8. The Integrity Organization. The effectiveness and success of any new initiative lies in its people. The people behind the scenes, operating and running the organization, are by far the most valuable resource the company has. The organization is a critical component of the facility integrity excellence model and is presented in Chapter 8.
9. Continuous Improvement. Facility integrity excellence model continuous improvement focuses on ongoing review and improvements to facility performance as well as facility integrity management processes. It details key performance indicators in a series of dashboards that are presented in a hierarchical reporting system in order to convey the right information to the right level in the organization.

10. Implementation of FIEM. Organizations are about people, their development, enhancing their performance and building the organization on their performance. FIEM considers the difficulties when introducing change into organizations. No matter how welcoming an organization is to change, it will still face a degree of employee resistance to change. This chapter presents tried and tested methods for effectively managing change in organizations and ensuring implementation of facility integrity management systems can be achieved successfully.

11. Facilities Integrity and Strategy. Chapter 11 explores integrity management strategy, which includes the development of a strategy framework. The framework includes development of an integrity policy and strategy along with specific requirements for the systems and personnel which encompass all of the necessary roles and responsibilities for integrity management.