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RISK MANAGEMENT AND RELIABILITY

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Gulf Society For Maintenance & Reliability

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CONTENTS

أصول Osool

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GSMR الجمعية الخليجية للصيانة والأعتمادية Gulf Society For Maintenance & Reliability

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Dear Valued GSMR Member,

We, the Board of Directors of GSMR, are pleased to welcome you to this new term. We congratulate the previous term, under the leadership of Mr. Eyad Basrawi, for the many achievements and stellar contributions of the society and its members. GSMR has spearheaded many initiatives and innovations in maintenance and asset management and we will continue to spread this culture with professionalism and integrity.

I would like to take this opportunity to thank my colleagues, the members of the newly elected Board of Directors for their confidence in me. We will do our best to strengthen GSMR and continue the great work that our colleagues in previous terms have built for this society.

GSMR has played a pivotal role over the past decade as a center for sharing knowledge in the Gulf in the field of maintenance and reliability and the cataclysmic events that shook the world in the past two years have only stressed the urgent need to develop maintenance and reliability technology and to develop research and innovation in these fields.

The society will work to stimulate this environment by taking advantage of the creative minds in the Gulf region and expanding the circle of communication with maintenance and reliability agencies around the world so as to make it easier for the members of the association to benefit from international expertise and technologies. We will also work to activate the role of members in the society and enable them to be a key partner in the industrial sector and its development in all GCC countries in an effort to provide more value to achieve the visions and aspirations of our leaders—the leaders of the GCC countries.

We are optimistic about the many opportunities that await us. We are very excited to host our flagship event once again—MAINTCON 2022 will be even bigger and better this year. This is only the start of a shift in direction and energy and we hope that this year will continue to give us more opportunities, and allow us to create more impressive work. On behalf of GSMR's Board of Directors, I wish you a happy, safe and prosperous 2022.

Saad Ibrahim Al Shamrani

Chairman

Gulf Society for Maintenance and Reliability

ANNUAL GENERAL ASSEMBLY 2022

BOARD OF DIRECTORS
2022 - 2024

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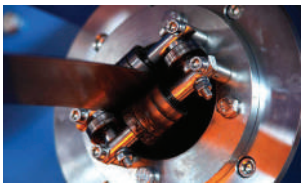
GSMR

GSMR hosted the Annual General Assembly meeting 2022 at Ramada City Centre, Kingdom of Bahrain which witnessed a great turnout of members. The audit report for the term 2020-2022 and progress report were shared with the members. The meeting came to an end with the much-awaited elections for GSMR's Board of Directors for the new term 2022-24.

Board Member
Ibrahim Hadi

Board Member
Ahmed Al Khaldi

Vice-Treasurer
Nader Milibari



Original Equipment Manufacturer (OEM) Spare Parts Monopoly Can Kill Your Plant's Reliability

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THE PROBLEM:

As highlighted with this intensive title, spare parts monopoly is literally considered one of the enemies that many professionals from reliability and maintenance sectors can easily nowadays stumble upon due to mainly the lack of asset management maturity inside the organization where the organization is required to determine the cost of ownership for any asset ahead of time. Therefore, spare parts monopoly can dramatically increase the total cost of ownership, especially during the operation and maintenance lifecycle.

SUCCESSFUL APPROACH

Saudi Aramco (WRDD) deployed new reliable ways to overcome the monopoly of spare parts by OEMs. Asset management is an important driver of the core operational excellence elements to ensure delivering the maximum value for the assets. During the maintenance phase, this OEM monopoly dilemma is well- addressed with an initiative called "Reverse Engineering" but does not necessarily only mean 3D printing technology as many have misinterpreted, rather it can be more of a design modification towards improved performance. The story began with 12 air compressors screw-type operating critically in one of the inert gas systems related Saudi strategic storage plant. The maintenance strategy for these compressors used to be time-based depending on compressors working hours which is 40,000 or 5 years to be overhauled whichever comes first as recommended by OEM. It was identified that the material cost provided by OEM and maintenance strategy provided is not powerful due to it being conservative and the high-cost approach associated with each overhauling service is 70% of the original price of a new compressor. Nevertheless, Root Cause Analysis (RCA) was conducted to identify all potential causes to improve the compressor maintenance cost. It was searched and discovered that using one of the approved non-OEM products utilizing reverse engineering capability will provide superior quality and significant material cost saving which is sourced from a non-OEM manufacturing company located in the UK possessing extensive experience in reverse engineering capabilities to provide Screw Compressor spare parts.

THE POSITIVE OUTCOMES

Saudi Aramco has successfully created operational excellence value for replacing these air compressor elements (spare parts) after identifying major problems with OEM compressor who is monopolistic and provide high-cost OEM elements (spare parts) designed to wear out at 40,000 working hours and cannot be refurbished. In order to avoid any risks, trial project was successfully partnered with central engineering and non-OEM company to confirm the quality of the spare part fulfilling Saudi Arabia's harsh environment. The new spare parts are predicted to have a better life with 70% less cost than OEM spare parts and anticipated savings from the deployment and use of these elements exceeding $ 1 MM annually company-wide. It is worth mentioning that, the new core elements coating design has been also improved to withstand 250oC high temperatures better than OEM which withstands only 220oC. as a result, this has improved the compressors' operational wear-out.

Best Apps

for Maintenance, Reliability & Asset Management

With the future of work being digital, we have rounded up some apps that will make work in M&R and Asset Management more efficient and effective.

MaintainX is the world's first workorder software solution designed with real-time chat functionality, and one of the world's first platforms designed specifically for smartphone usage. Companies can digitize and take away from the clipboard: -Safety Procedures -Environmental Checklists -Tooling & Gauge Reporting -Maintenance Procedures -Auditing/ Inspection Workflows -Training Checklists. Companies can get started for free.

Gage List is a simple online gage calibration management software solution that makes maintaining tool calibration records easy and economical. According to one review "The ability to assign gages and assets to people and locations is very helpful in physically tracking down equipment when its time to calibrate".

Tofino is a single integrated cloud solution that delivers Computerized Maintenance Management System (CMMS) capabilities. This is an inexpensive and efficient inventory management system for tracking and reordering.

Maxpanda is a highly-customizable CMMS software that improves the process of creating, managing, and reporting maintenance routines for businesses. It offers easy cost tracking and seamless communication for teams while enhancing user experience by leveraging intuitive interfaces.

TRAINING AND DEVELOPMENT IN MR&AM

Professional Certification

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This article is a follow up of the earlier article written in October 2021 issue of Osool about Training and Development, and concerns the issues related with the Professional Certifications in the field of Maintenance, Reliability & Asset Management (MR & AM).

The earlier article can be summarised in the following paragraph:

The effectiveness of MR&AM strategies, which are crucial to the business success of an organization, depends on the personnel who plan, implement, execute, and manage those strategies".

Therefore, issues relating to the Training & Developments and Competence building of the people responsible for Production, Maintenance, Reliability, and Asset Management need to be given the same weight and integrated with the rest of the decisions taken at the corporate level for managing the field of "MR&AM".

Some of the key objectives of the Training & Development Plans are:

- "Improve competence of staff involved in MR&AM"
- "Promote Reliability Based Culture"
- "Develop Staff Leadership competency to facilitate effective implementation of Reliability and Maintenance Programs."
- "Keep the talents and their competency relevant and supportive of the business goals of the company."
- "Ensure the changes are understood and accepted at all levels of the operation, maintenance, and reliability workforce."

Training assignments and expenditures must be viewed as any other expenditure from a business perspective and must be based on a return on investment. Some of the returns may be short term in the form of low hanging fruits from exchanging of ideas and sharing of case studies during the assignment, and some of the returns are of long-term nature.

With regards to the Professional Certification aspects, it is a known fact that the values and benefits from the Training assignments are at different levels, the highest of these levels are those that are associated with empowering the individual to take on higher responsibilities in the Organization, and those that enable an individual to become Certified and recognized as a Professional.

For this purpose, GSMR has undertaken an important task to develop the BoK document for the field of MR&AM. To help achieve best-in-class MR&AM performance, the GSMR Body of Knowledge is based

on five pillars with emphasis on covering the Asset Life Cycle:

PILLAR 1: MR&AM Strategy.

PILLAR 2: Asset Reliability.

PILLAR 3: Maintenance Work Processes.

PILLAR 4: System & Technology.

PILLAR 5: People & Leadership.

The GSMR Body of Knowledge (BoK) offers specialized guidance to individuals, leaders, managers, and service providers working in the field of Maintenance, Reliability & Asset Management (MR&AM) both internal and external to organizations.

The Certification Process, which is accredited by an International Organization, aims at developing Professionals in the field of MR&AM with a balanced all-rounded knowledge of all aspects and phases of the Asset Life Cycle, through experience and academic learning, complemented with the need to pass an exam to become recognized and certified as a Professional.

The benefits of Professional Certification through a consistent BoK are apparent to practitioners in many organizations, and can be summarised in the following points:

- Visibility and Recognition.
- Improved knowledge in MR&AM.
- A tangible training goal and direction.
- Setting a common competency standard and uniformity between Plants and Companies.
- Provides clear career path for hiring and promotions.
- Assist in selections for higher positions.
- Improves hiring opportunities.
- Better pay scale for the individual.
- Provides more value to the Organization.
- Possibility for the professional to demonstrate knowledge
- Improve Leadership Skills.

WOMEN SPEAK

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Petroleum refineries aim to minimize the environmental impact by producing cleaner fuel, which requires continual technological innovation, adapt best work practices and optimization. For that, women play pivotal roles in the technical services group in Al-Zour Refinery, Kuwait. Women get equal opportunities to develop their career and execute their personal development plan in KIPIC. In fact, refinery work culture is transforming and women are encouraged to manage and lead the various projects, studies and optimization initiatives. They are also recognized to be equal performers in their professional duties and proven to be successful in work-life balance. Even though women play a fundamental role in preserving social heritage and culture, they are significantly contributing to the sustainable socio-economic development of Kuwait. Furthermore, it is evident that women are catalyzing the culture of Making More Possible at KIPIC. Thus, it is equally important to further inspire and enable the next generation of women leaders in taking more challenging roles and responsibilities in their professional endeavors. This will in turn boost their confidence and self-esteem.

maintCon

6th MIDDLE EAST MAINTENANCE & RELIABILITY CONFERENCE

2022

27-30 November

Gulf Hotel, Kingdom of Bahrain

Industry 4.0 - New Era in Maintenance & Reliability

Greetings!

We have all been through a year where the pandemic has had a huge impact on our lives and economies. In order to organize a successful gathering and to make each participant's time worthwhile, the organizing committee has postponed the event to 27th – 30th Nov 2022.

WWW.MAINTCON.ORG

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CONFERENCE TOPICS

Facility Management

Maintenance & reliability professionals development

Maintenance & Reliability during pandemic – opportunities & challenges

Digital Maintenance Supply Chain- Smarter Asset Data Management & Quality

Turnaround & Inspection, Planning & Execution Digitization

Smart Tools for Reliability, Maintenance & Asset Performance Management

Maintenance 4.0 - Maintenance & Reliability Business Transformation

Big Data & Predictive Analytics Mobile maintenance in an Industry 4.0 Planning & Scheduling Enabling Digital

Fundamental Maintenance Insights Transformation of CMMS applications Integrated Intelligent Asset Management

IIoT & the Internet of Condition Monitoring applications

Maintenance Planning & scheduling Transformation

For further details regarding the Exhibition, please contact:

The Conference Secretariat
MAINTCON 2022, Bahrain Society of Engineers, P O Box 835, Manama, Kingdom of Bahrain.
Tel: +973 17 810733, Fax: +973 17 827475
Email: conference.manager@bse.bh

TECHNICAL PAPERS

Every issue, we feature our members' technical papers wherein they make case studies on problems solved, best practices and risk management solutions they have found helpful in their own companies. We also host monthly webinars that showcase our members' rich technical knowledge and expertise with the aim of making GSMR a knowledge hub that contributes to the diverse culture of Asset Management, Maintenance & Reliability in the Gulf.

An Effective Tool to Achieve Organizational Objectives

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METHODS TO TREAT FAILURES:

Failures (Including Incidents) can occur in assets, asset management and asset management systems which will compromise the organization's ability to achieve its desired objectives.

The performing organizations, more often establishes processes to control nonconformities and their associated consequences, to minimize any adverse effects on achieving the organization's objectives which are based on stakeholder's needs and expectations.

There are many ways to find out the non-conformities, its impact, causes and best-balanced solution to fix the problems and its re-occurrence.

The processes for investigation should not treat the symptoms of failures but focus on latent causes (Root causes) which will prevent for re-occurrence, once treated carefully.

Such applicable processes, procedures and activities should be utilized by RCA Facilitator/Investigator according to the situation, risks and opportunities and should consider strategic and operational non-conformities within the organization.

Treating Asset related Failures:

Most methods applicable are contained within the root cause analysis domain and include relational, causal, probabilistic and event-based methods.

1- Advance cause and effect diagram,
2- Ishikawa diagrams
3- Causal tree
4- Fault tree
5- Event tree
6- Logic tree.

Further guidance on some of these methodologies and principles in details can be found in IEC 62740 and IEC 62508.

Treating asset management system failures:

Treating asset management system Failures should be one of the objectives of organization. There are methods available to treat systematic failures in asset management systems.

1-Management oversight risk tree (MORT)
2-Incident cause analysis method (ICAM)
3-Tripod beta method (TRIPOD).

Treating asset management system failures:

There is a famous saying **"To err is human".**

Management of Assets is carried out mostly by humans. Most failures are related to decision making which are contained within the human error and risk analysis domain.

To treat human error- and cognitive-based failures (errors), there are several methods as listed below.

1- Cognitive event tree (COGENT)
2- The reason model
3- Technique for human error rate prediction (THERP)
4- Human error analysis (NASA method).

BEST BALANCED SOLUTIONS:

Best balanced set of solutions should be SMART and targeting the root causes.

Solutions should be of two types:

Corrective Actions:

These are usually short-term actions which only fixes the problem understudy.

Preventive Actions:

Preventive actions are long term actions which are proactively implemented in order to prevent similar problems. Such actions are related to leadership skills enhancement, behavior and practices via corrective decision making, change management, training and the development of competence at respective levels in an organization.

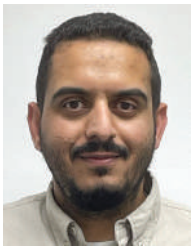
LEADERSHIP ROLES IN TREATING FAILURES:

Treating failures in an organization becomes easy and very effective when leadership is supportive at all levels and there is no conflict of interests involved. Often organizations fail to treat the problems when such tools and Techniques are compromised.

Reference: ISO 55002:2018

Risk Assessment: The Foundation of Project Design

Analyzes the Banqiao dam case study using risk assessment tools – Fault Tree Analysis and Reliability Block Diagram – to highlight the importance of risk assessment in the design stage of any product.



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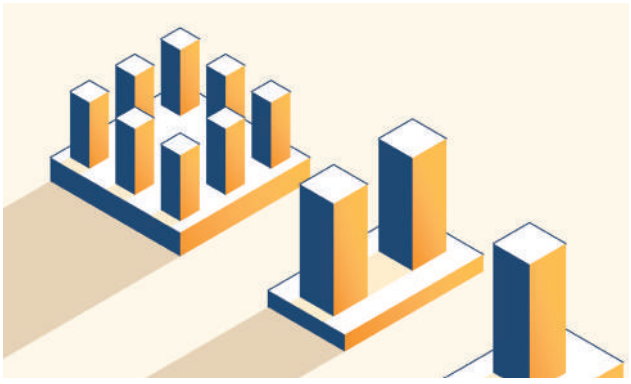
Failures are not accepted in our industry. This concept is stressed upon in case of potential failure concerning safety and the company budget. This makes it clear that designers must focus on means of learning other than toleration of failure. It is even arguable which type of learning shall be introduced to the designers in order to raise their experience in their field. The paper recommends the use of simulators at the university level. Yet, there are constraints that won't convey the contents to be learnt such as number of students, time restriction and resources availability. However, simulators cannot represent the real time environment to the trainee and won't consider every single contributor that is taking place in real life.

On January 15, 2009, Chesley Burnett "Sully" Sullenberger piloted the US Airways flight 1549 out of New York's La Guardia airport. After the airplane took off, the plane experienced dual engine failure as a result of a bird hitting the engines. Sully, who had 40 years of experience, decided to land on the Hudson river in Manhattan rather than landing at the closest airport. Upon landing on the river, the captain succeeded in saving 155 passengers on the plane. It is worth mentioning that landing on a river was never successfully achieved until then. Despite his quick thinking and successfully saving 155 passengers, he faced trial. Simulators showed that landing at nearby airports was possible thus accusing the captain of risking the passengers' lives.

Upon several trials and simulations, the captain was almost sentenced as guilty, however, the national transportation safety board supported the captain's decision to land on the river rather than the nearest airport. It was later found that the simulators were designed for cruising altitudes and so, did not consider the related factors after immediate take-off. The case highlights the potential failures in not considering all related factors and the role of human experience in controlling a situation. By extension, it highlights the importance of designers learning from real time experience that is usually based on success and lessons learnt from previous failures.

Another case study presented concerns the failure analysis of a highway sign structure and design improvement. The failure analysis method has been applied to the premature failure of fracture experienced at the sign support structure as a result of high wind speed. The failure analysis applied considers a stress analysis on the support structure and strength evaluation. Upon evaluation of the existing structure and the impact of the wind speed on the structure by applying higher stresses at different locations of the structure, many options were identified to improve the design. Although the standard requirement for such a design was met in one of the options, the designers decided to go with the one that has the highest load transfer from the braces to the column, considering safety and redundancy.

Although both cases clearly indicate how failure analysis helps experts and designers analyze a situation and improve design or take the right decision, neither offers a clear process for the designers to learn from failure and improve design. Also, both case studies imply that feedback to designer is necessary for further evaluation and understanding of failures in order to come up with a different prototype design that overcomes the undesirable event.



BANQIAO DAM FAILURE

The Banqiao dam was constructed in 1953 on the Ru river in Henan province with a storage capacity of 492 million m^3 and 24.5m height. The basis of this engineering structure was clay core earth-fill dam. In 1975, the Henan province experienced a rainstorm with around 1631 mm of rain for five days. As a result of heavy rain and partial blockage in the spillways, the dam experienced overtopping that eroded the earth-fill and resulted in the breach of the dam. This catastrophe is considered as one of the largest humanitarian disasters of the 20th century.

The failure of the dam was a result of different factors. These factors included reducing the costs by considering small-to-moderate floods in the design stage and the partial blockage in the spillways that caused the overtopping of the dam, which is related to maintenance management. The flooding from the other dams that got damaged at the same time resulted in the accumulation of flooded water – around 600 million m3 wall of water behind the dam. Also, the safety factors were not considered in constructing the dam, which was close to the cities, risking people's lives. This catastrophe resulted in 26,000 fatalities and around 200,000 deaths after the incident took place as a result of illness. Although 11 million people survived the event, they became homeless as a result of the destruction that the flood caused.

FAULT TREE ANALYSIS & RELIABILITY BLOCK DIAGRAM

Note: The output of the FTA analysis will be used as the input to structure the RBD in order to define the vulnerable block. The AND gate represents that item needs to occur at the same time; the OR gate represents that any occurrence of the items will be enough.

These engineering techniques were applied to the subject case study to identify the factors behind such a catastrophic event. The FTA analysis in Figure-1 shows that there were so many factors that caused the disaster of the Banqiao Dam:

- Designing the dam for low to moderate flood to reduce costs, lack of risk assessment and neglect of safety factors throughout the design phase
- The erosion of the dam's core, which was not noticed as a result of the non-availability of sensors to provide pre-alarm to the people living around to evacuate the area ahead of the failure alarm
- Locating the dam at the subject location due to a lack of risk assessment and non-availability of the emergency procedure
- The spillways partial blockage as a result of sedimentation blockage that would have been noticed and cleaned if proper maintenance management was set or any new self-cleaning technology was used
- Accumulation of water from other dams that would have been avoided if a contingency plan was set for each dam
- Unsafe condition where the weather forecast was not predicted in addition to the unavailability of an evacuation plan.

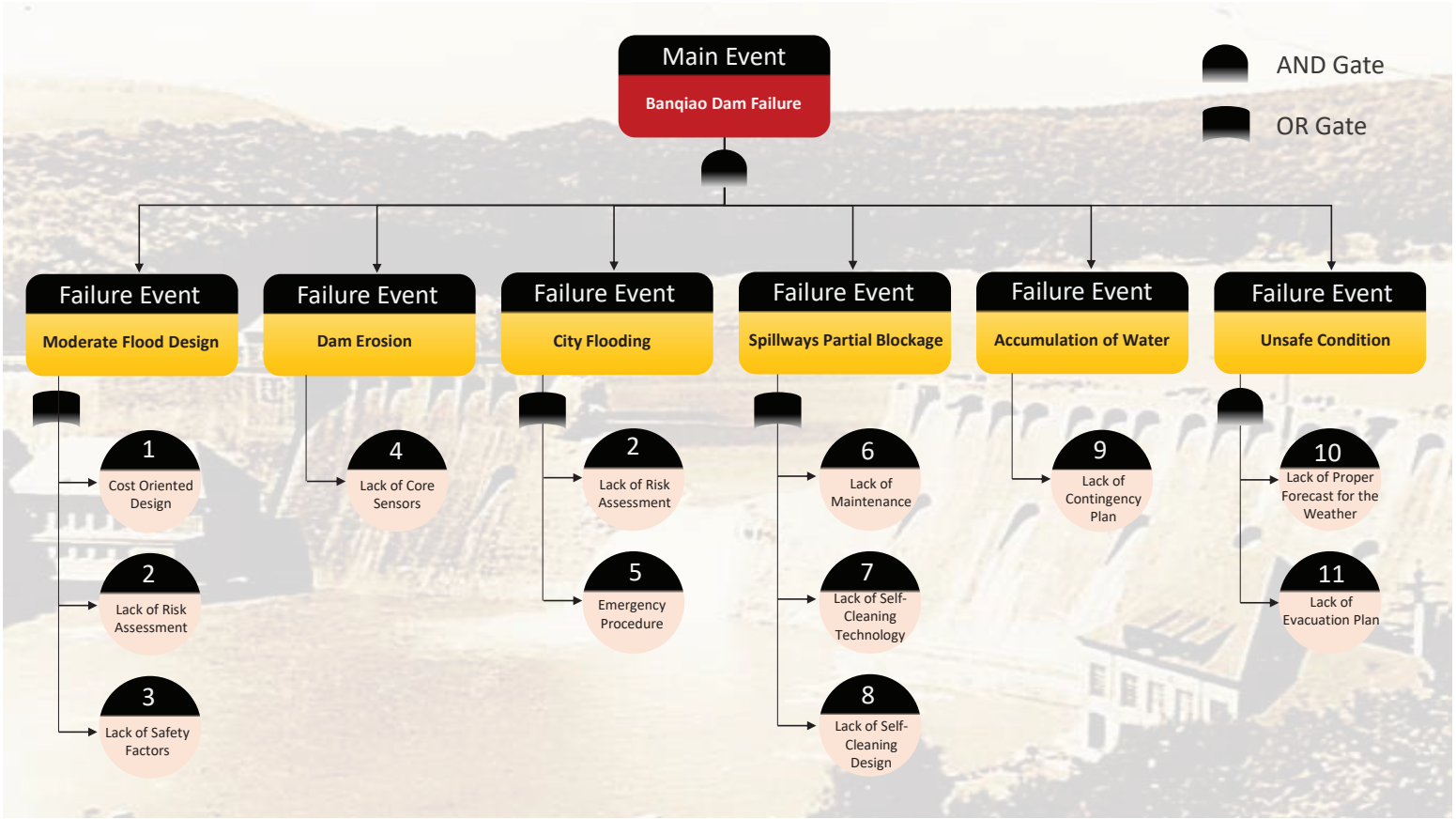


Figure 1. Fault Tree Analysis of the Banqiao Dam Disaster

This FTA can be illustrated into an RBD with parallel and series arrangements representing the AND and OR gates respectively. Also, the numbering added to the FTA represents the basic events that are going to be utilized for the construction of the RBD diagram.

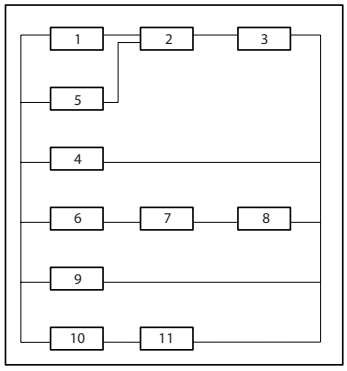


Figure 2. Banqiao Incident Reliability Block Diagram

The RBD shows parallel arrangement that is representing AND gate which needs all items to occur to trigger the incident. Based on the RBD illustration, if any of the basic events are eliminated or improved, it will help avoid the disaster. Box number 2 is found controlling box number 1 and 5, hence, more efforts must be spent there.

Box number 2 represents the risk assessment needs to be conducted ahead of the design of such dams to eliminate such an incident. During risk assessment, the engineers or the designer should consult other parties that specialize in the same field and undertake crisis management to determine all risk related factors to be considered during the design.

Lessons Learned

- Risk assessment shall be part of any design to consider all required mitigation needed in the design to eliminate the risk or at least mitigate it.
- Never compromise safety for cost reduction. If cost is a constraint, then project feasibility study should take place while considering all other important factors that directly impact the allocated cost for the project.

Advantages & Limitations of the Techniques

The advantages observed in using the FTA and RBD to structure the Banqiao incidents were the simplicity in illustrating the problem into a very simple structure that can be read from the top event downward to the bottom of the event initiator, and clearly identifying the root cause of such events. The RBD structure also helped in enhancing the thought process to determine the main contributing factors to be focused upon rather than consuming time and money on the other factors that might lead directly to the prevention of the incident or might need a focus on other interrelated items.

The disadvantages observed throughout the process of developing the FTA of the subject case is that the analyst needed to be enriched with knowledge in the field of dam construction, which is believed to construct a much better FTA. The sequence of the events is not describable and arrangeable in a way to understand the sequence of the events that took place that resulted in the incident. Moreover, there is a possibility of improperly assigned gates based on the understanding of the analyst from the bottom of the tree climbing to the top event while other analysts could have different assignments for each gate. Also, there might be a possibility that the analyst doesn't consider all the basic events that could result in the top events either due to the lack of knowledge about the tools or the analyst focusing on one side that he might be interested in.

So, if uncertainty is raised throughout the development of the FTA, the same potential applies to the structured RBD as it is built based on the output of the FTA. In the case study provided, risk assessment was mentioned twice as a basic event of the FTA as a result of consideration of the FTA as a risk assessment tool and to ensure a safe process is conducted throughout the design to cover for the lack of knowledge in the field of dam construction. The RBD did not provide the proper sequence of the basic events to happen, although it offered simplicity in identifying the root cause in the RBD structure. This could lead to improper consideration through the model leading to focus on the number on the boxes rather than the priority of each basic event since the boxes in the RBD are seen as numbers rather than factors. Prioritizing the events would give adequate focus to each event, considering the priority of that event and the severity that it may cause.

RESOLVING SUDDEN HIGH-RISE VIBRATION IN HIGH VOLTAGE SYNCHRONOUS MOTOR

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ABSTRACT

- This case is about a site vibration issue on an HT Motor driving a Gas Compressor. When the compressor was in operation at normal condition (design load), vibration at Motor NDE suddenly started rising, from normal operating vibration amplitude to trip setpoint, in a duration of approximately 1 hour and caused the machine to trip.
- Troubleshooting and analysis was completed to identify the high vibration cause. The high vibration of 340 µm Pk-Pk (14 mils Pk-Pk), higher than nominal bearing clearances (270 µm), was recorded in the Motor NDE journal.
- This case study outlines how the high vibration issue was successfully diagnosed by analysis of shaft vibration data during motor load and no-load condition.
- Based on analysis, "Shaft Thermal Bowing" was diagnosed as the cause of high vibration at Motor NDE. Rotor bow physically causes an imbalance in the rotor, which was clearly observed in vibration Spectrum, Orbit & Time-waveform plots.

Lessons learned related to the vibration incident were recorded, and a robust maintenance plan to avoid unplanned downtime.

MACHINE INFORMATION

Main Equipment Type	:	Synchronous Electric Motor
Motor Model	:	1DR2332-6MN02-Z
Motor Manufacturer	:	Siemens AG
Power/RPM	:	5000 KW (6700 HP) / 1800 RPM
Voltage	:	13200 KV
Bearing	:	Hydrodynamic Bearing (Make-RENK)
Monitoring	:	Two vibration detector and Bearing Temp Detector
Lubrication	:	Pressurized Lubrication ISO VG46
Driven Equipment	:	Multistage Centrifugal Compressor with Intermediate Gearbox
Operating Parameters	:	Ps = 461 Psia, Pd = 900 Psia. Flow = 188 MMSCFD
Capacity Control	:	Suction Valve Throttling

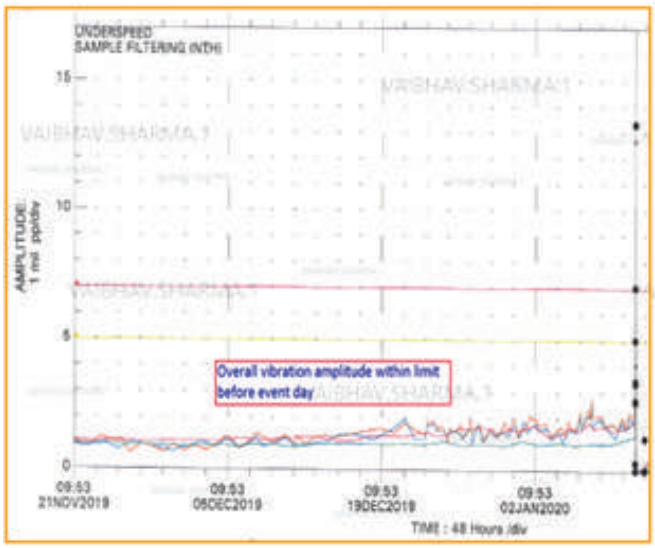
PROBLEM DESCRIPTION

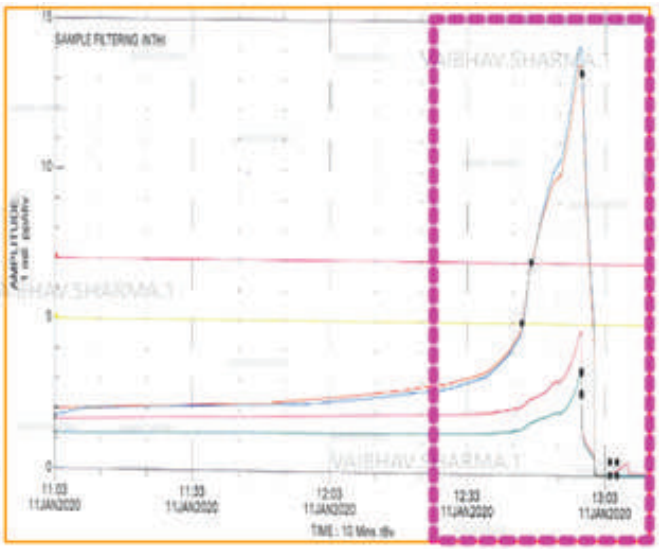
- Subject Motor is Siemens AG make Synchronous Motor, which drives Centrifugal Compressor (LNG Separation Tower Overhead Gas Compressor). Motor experienced high vibration at NDE along with change in vibration amplitude at DE.
- Sudden rise in vibration amplitude was observed at motor NDE during normal and steady operation. Vibration amplitude reached trip limit at motor NDE in approx. 60 mins from the moment it started increasing which initiated motor trip logic on Hi-vibration.
- Motor Vibration Alarm / Trip Setpoints: 5 Mils Pk-Pk / 7 Mils Pk-Pk

- Initially Instrument team verified for vibration detector health. After instrument confirmed vibration is real, motor was isolated for further investigation.

ANALYSIS

- Trend analysis of motor current during high vibration event to identify if the cause of vibration is due to change in motor load.
- Trend analysis of motor vibration amplitude to identify when the change in vibration amplitude started. Rise in vibration started all of sudden and was not gradual.
- Vibration analysis was done utilizing Bently Nevada System 1 software. Spectrum analysis, Orbit plot analysis, Waveform analysis and shaft centerline plots were utilized in root cause analysis of vibration.
- Vibration analyzed indicating reverse precision, sign of rubbing, increased pre-load and change in shaft centerline during the high vibration event.
- Co-relation in motor NDE bearing temperature and vibration amplitude observed which confirmed that there is a possibility of rotor bow.
- Unbalanced was ruled-out as during the event no change in motor DE vibration amplitude observed.





IMMEDIATE RECOMMENDATIONS

Based on the investigation, the following were recommended:

- To inspect exciter assembly mounted at NDE.
- To inspect motor NDE bearing

OBSERVATIONS

- Scoring marks observed on NDE bearing top half. Overall bearing condition observed good. Bearing clearance observed within limit
- No damage observed on motor cooling fan.
- Overheating signs observed on excite diodes
- During inspection no physical damage in components were observed and hence, it was decided to conduct motor solo run for further analysis.
- High vibration observed at motor NDE during solo run.
- Vibration Spectrum, Orbit and Time-Waveform had similar observations in comparison to initial high vibration event.

ROOT CAUSE

- Thermal bowing in shaft at motor NDE due to “damage in exciter discharge resistor”.
- Damage in discharge resistor caused current leak to shaft which caused thermal bow.
- Exciter assembly is installed at motor NDE.

LESSONS LEARNED

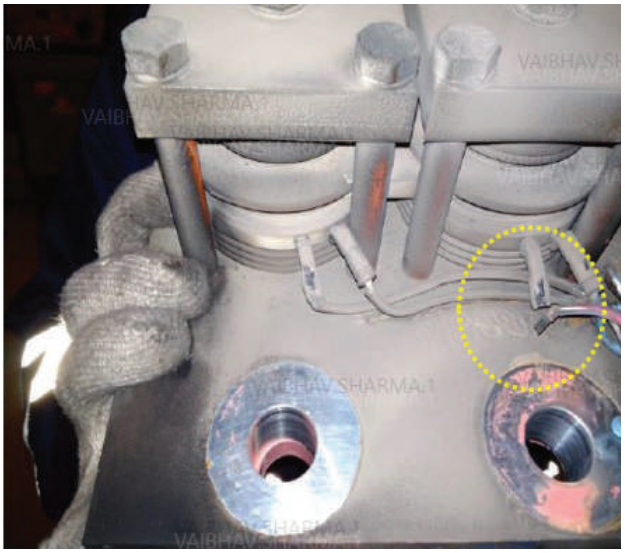
- HT motors were not covered in PM program. The routine PdM program found adequate.
- HT Motors Condition Assessment was carried out one year before the incident. No abnormality was reported in subject motor. But still motor experienced high vibration issue within one year of assessment. This indicates not all faults are detectable.

WAY FORWARD

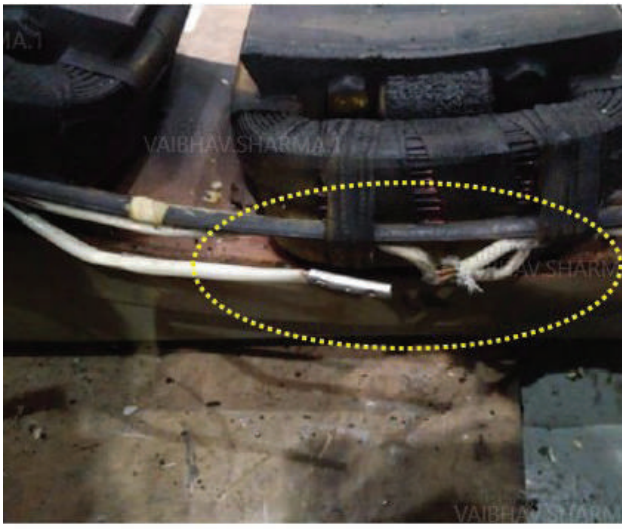
Minor and Major invasive PM program was developed for all HT motors. Total installed quantity of HT motors 36 ranging from 5000 to 21000 HP.

- **Minor Invasive Program**
- Inspection of following every two years
- Power Supply Cable Connections and Junction Box inspection

EXCITER INSPECTION



Exciter Thyristor Connection found disconnected

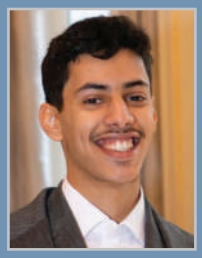


Exciter Pole-to-Pole Connection Found loose

- Brazed connections
- Terminal bushings
- Space heaters functionality test
- Motor windings insulation healthiness checks
- Exciter components inspection (Exciter stator windings, Diodes, Cable connections, etc.)
- Cleaning of filters and ventilation ducts.
- Borescope inspection of cooler tubes
- **Major Invasive Program**
- Complete overhauling of motor every 10 years.

INTERNAL LEAKAGE OF OIL COOLER (HEAT EXCHANGER)

IN A GAS ENGINE IN WA'AD ALSHAMAL FACILITY – NORTH ARABIA



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The necessity for the adoption of transformational technologies and unusual solutions will be much more apparent in the Middle East in the future. The region is experiencing multiple changes in the oil and gas business models and frameworks, especially with the mission of increasing the utilization of natural gas as an environmentally friendly solution compared to oil. Saudi Aramco's project of investing in North Arabia's unconventional gas fields operations development with the usage of gas engine generator sets as primary power producers show the versatility of the industry in taking new stances as dictated by regional challenges.

It all started when the line maintenance unit was performing their usual PM tasks, the coolant hose was observed to be damaged (wear and tear), and the maintenance team tried to empty the flexible hose to replace it. The reliability team noticed that the coolant contains sludge and appeared to be highly contaminated, displaying atypical color and texture compared to a clean coolant. A coolant sample was sent to Aramco Lab facility in Abqaiq, and it was determined that high amounts of hydrocarbons were present. Upon further investigation, these hydrocarbons seemed to match the characteristics of the lube oil. The lab investigation results indicate, through Gas Chromatograph hyphenated to a mass spectrometer detector (GC-MS), that the lube oil from the same engine shows similar characteristics to that of the contaminated coolant.

The team started the investigation by looking at possible locations of close contact of the lube oil and coolant closed circulations inside the engine. First, the oil level was checked and showed high levels in the dip stick and the oil looked normal. Oil was drained and the oil did not appear to be contaminated. As per the engine's conditions, the pressure of the oil was higher and thus it was expected that contamination to be taking unidirectional impact. Another check was conducted by opening the cylinder covers and inspecting them, no moisture is observed. Hence the possibility of water-contaminated lube oil was eliminated. Also, it was noticed that the coolant/water piping after the Oil Cooler (Heat Exchanger) was contaminated with oil as opposed to before it when the coolant pipes showed no signs of lube oil presence. The location of the leak was determined a few days later through hydrotesting in an appropriate facility to be in the oil cooler. See Figure.1 below of the Oil Cooler which is a typical cylindrical shell and tube type.

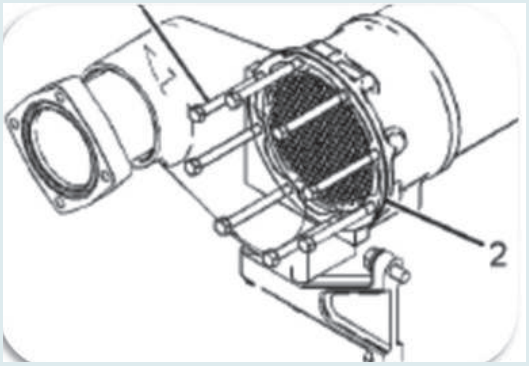

Figure.1: Oil Cooler Design (Diagram Showing One End)

When it came to the root cause, it was mainly thought to be the lower-than-expected stated lifetime of the Oil Cooler itself. Higher pressures of oil in the Oil Cooler caused it to go into the coolant. PM was revised and recommendations were obtained from OEM to clean and/or replace the oil cooler as necessary based on running hours of the engine.

The issue did not end by replacing the oil cooler, the whole system of the engine and radiator were fully contaminated and residues of lube oil reside in the closed loops. As per OEM recommendations and best practices, the system was flushed multiple times with 90% distilled water and 10% Cooling System Clear – Quick Flush as a typical procedure to remove oil and sludge residue from the radiator and cooling system. The procedure took a few days in North Arabia's facility due to harsh weather conditions and the large size of the radiator of the existing gas engine. However, the engine was brought online in less than a week successfully!

Lesson learned were various. First, revising the existing PM and ensuring its accuracy based on the geological and climatic conditions of the region is of necessity. Second, having vertical radiator design might have been a better choice as residuals occupy less surface area than horizontal one, speeding-up the process of flushing and cleaning the system without disassembling the radiator all together. Lastly, increasing the frequency of sampling of coolant might have resulted in spotting the issue earlier and fixing it rapidly before it contaminated and resided in large quantities in the radiator

Infrared Thermal Imaging

Used In Tank Content Detection

INFRARED THERMOGRAPHY CONSULTANT AND TRAINER – LEVEL 3

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Infrared Thermal Imaging is no newcomer to the world of maintenance. The art and skill has been lurking in the arena for over 50 years on various levels around the globe.

Out of the bunch of devices currently in the market, the handheld portable thermal imagers employed in the industrial environments can deliver amazing results in the hands of trained professionals. The range of applications include but goes way beyond Electrical, Mechanical, Civil, Buildings and other non-conventional applications. Since thermal imagers in the market today is segregated into several levels based on their capabilities, selection of the correct imager is necessary.

The devices detect infrared thermal radiation emitted by all surfaces around us in a specific Spectral Band contained in the infamous Electromagnetic Spectrum. Most of the handheld industrial detectors employ the Long Wave Infrared Wave Band (LWIR) which is from 7.5 µm – 14 µm.

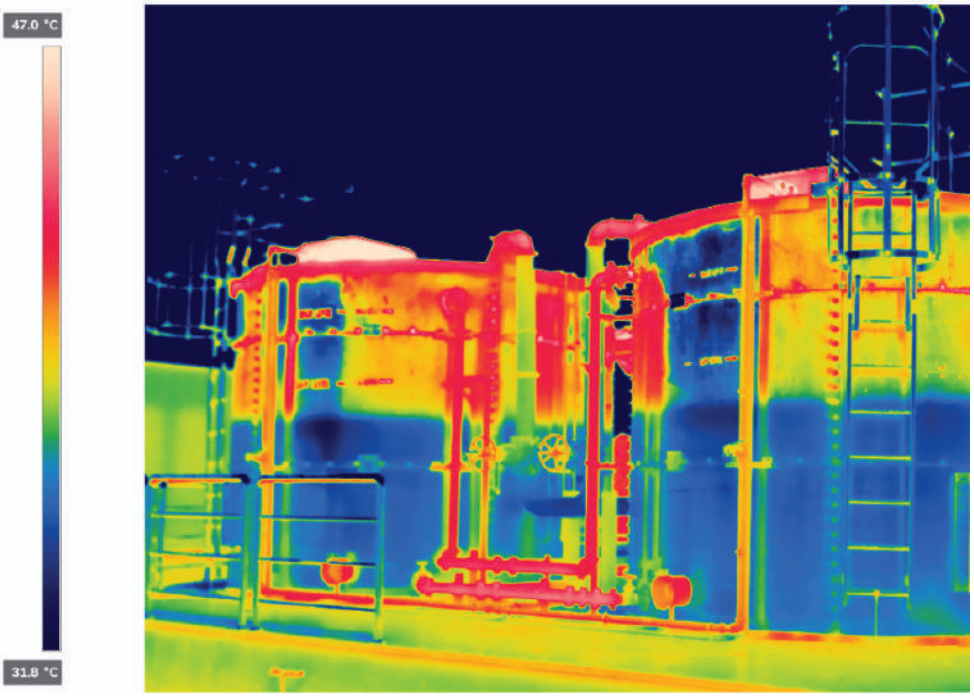


Fig 1 : Water Level in Steel tank (Equal Levels)

The interesting thermal pattern shown in the tanks is a result of the thermal behavior of different materials and mediums when subjected to specific conditions. Practically, these patterns are best achieved when typically top sealed tanks with different materials is subjected to solar loading over a period of time. During day time, the tank surface absorbs solar radiation and transfers the heat in to the materials stored inside. Inside the tank, typically on top there is a trapped air layer and the rest of the volume is filled with liquid. In addition to air and liquid, at some occasions depending on the medium, a solid layer (sludge) can also be observed.

As the first step in interpreting the thermal pattern seen here and to understand "why am I seeing this?", it is important to revisit a concept taught in basic thermal physics.

Specific Heat Capacity (SHC) of unit weight of a material, is defined to be its ability to gain heat when heated and lose heat when cooled. By definition, it is the "Amount of energy required to raise the temperature by 1°C of a unit mass of a given material" and measured in Jkg-1K-1 (Joules per kg per Kelvin). Materials or mediums such as air, majority of metals, carbon, glass, concrete, granite and a bunch of other materials have a relatively low SHC. On the contrary ; water, ethanol, paraffin, rubber, ice, wood, hydrogen, nitrogen, steam and other materials carry a higher number for SHC. As you can see, a particular family of materials (metals, gases, solids, liquids, non-metals) cannot be generalized for having higher or lower SHC as they are mixed in both categories. However, it is safe to say that all liquids are generally high in thermal capacity. Typical SHC values of several materials (measured at standard room temperature) are mentioned in the table below.

Substance	Specific Heat Capacity (Jkg-1K-1)	Family of Materials
Aluminium	900	Metals
Iron	450	
Copper	390	
Silver	230	
Hydrogen	14000	Gases
Air	718	
Nitrogen	1040	
Wood	1700	Non-Metals
Nylon	1700	
Rubber	1700	
Concrete	850	
Sand	800	
Ethanol	2400	Liquids
Paraffin	2100	
Water	4186	
Milk	3751	
Coconut Oil	2100	

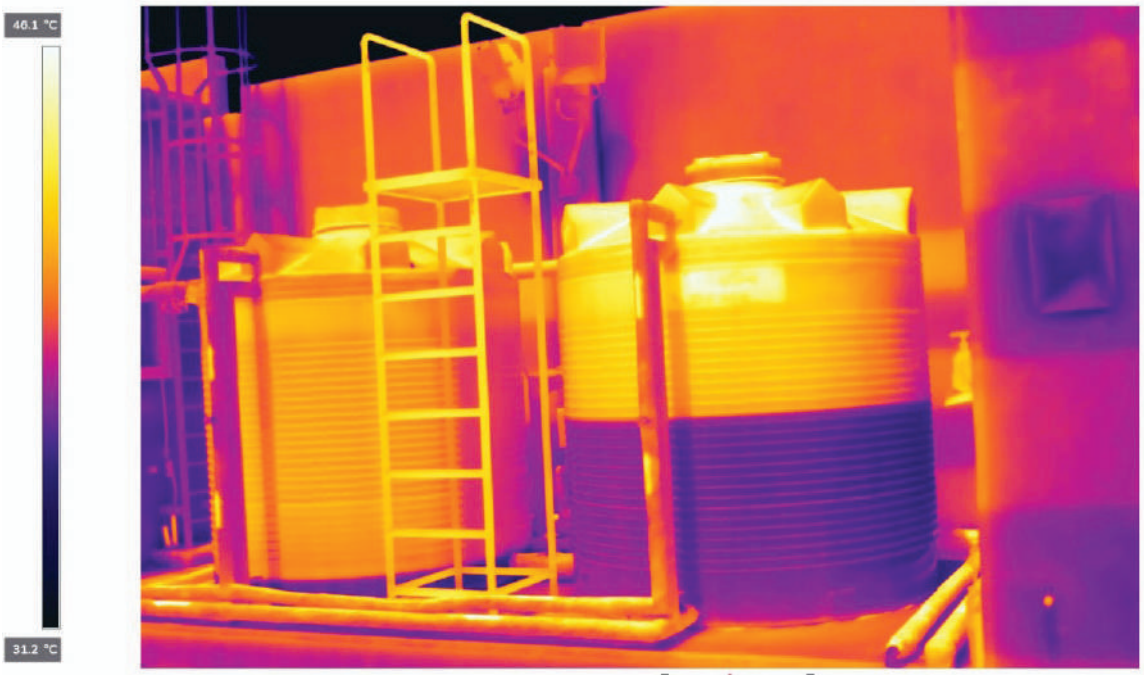


Fig 2 : Water Level in PVC (Left Tank empty, Right Tank Half Full)

Figure 2 shows the attempt made to detect the water level of two PVC tanks. The tank on the left is empty and the right is half filled. The thermal image employs the colour palette commonly known as Iron Bow. The temperature scale is given on the left of the image. The colour orange represents the higher temperature part of the image and purple represents the lower temperatures of the image. The image is captured using an ultra-high resolution imager with a detector size of 1024 x 768 Focal Plane Array in LWIR.

As the tank showing in the image is placed outdoors, it is subjected to direct solar radiation throughout the day. The tank is made of PVC and the thickness of the tank is comparatively low at around 3 – 5 mm.

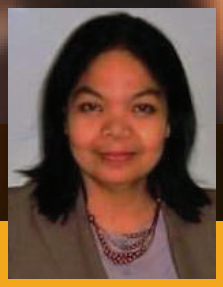
The tank top is closed and inside the tank remains trapped air on top and water at the bottom. Heat of the sun is transmitted to the tank surface in the form of radiative heat. When that happens, both the air and the water in the tank will start getting heated. However, note from the table above, that the SHC of the air is much lower (718 Jkg-1K-1) than that of water (4186 Jkg-1K-1). Hence, air needs much lower amounts of heat to raise its temperature and water needs a lot of heat to raise its temperature. To make things more uneven, the mass of the water in the tank is much greater than the weight of the air trapped inside the tank. As a result, air starts heating up much faster than the water. This major disparity in the rate of temperature rise will soon create a major temperature difference in the two materials as the solar radiation will continue to heat up the tank. Eventually after 7 hours of solar radiation on the tank, the temperature measured at the top of the tank (air) has reached 42 °C while the bottom half (water) has only reached 36 °C. Now the thermal pattern is evident and crystal clear.

The analysis on Figure 2 is identical to the above and the tank material is steel. In addition, an additional layer of sludge or oil on top of the water will also be visible since sludge and oil are having different SHC compared to air and water inside. Thanks to infrared thermography, we are able to see all the phenomena going on inside the tank without even entering the tank or making contact with any components.

However, a professional attempting to carry out content detection surveys can encounter challenges due to several circumstances. The tank built materials such as concrete and tanks with internal linings will not show distinct thermal patterns as we have seen in the figures here. In some parts of the world, the environmental conditions may not be suitable to carry out such a survey due to subzero temperature or inadequate solar radiation. In those cases, assuming proper precautions and smart understanding about the context can help them achieve a successful survey.

How PUBLICSPEAKING can help your career

Speak for Success!



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Public speaking is the act of speaking face to face with a live audience. It is also called oratory or oration and was also known as rhetoric during the time of the Greeks. Towards the mid-20th century a less formal and more conversational speaking style of public speaking became the trend with electronic tools also known as computer software enhancing public presentations.

Nowadays, public speaking includes any form of speaking to an audience, including pre-recorded speech delivered over great distances by means of zoom, Youtube and other technical devices. Then and now, public speaking or speaking in public has become not only a desirable habit but also a desirable skill.

Speeches in Public speaking cover a wide variety of topics from the simplest one like My Favorite Pet to the most complicated such as coding and other technology-inspired or related topics to serious ones like transcendental meditation and scientific discoveries such as a cure for cancer and the like.

As they say, public speaking may take different objectives depending on the occasion or event , place, time or atmosphere and speaker. Most of the objectives are to inform, persuade, entertain and to inspire. Whether one is a student, a professional or a small business owner, surely one benefits from improving or having good public speaking skills. Some of the benefits are:

1. **Personality development**- public speaking is a vehicle towards personality development as one gets to enhance his skills while engaging in the activity.

a. **Self-esteem or confidence is enhanced**- the more immersed one is in speaking before an audience, the better the self-esteem or confidence one gets. Each speaking opportunity serves as a rung

in a ladder that piles up and builds up to reach the top.

b. **Poise and bearing**- You should fake it till you become it- Amy Cuddy, Social psychologist.

As a public speaker, it is a must to observe correct poise and bearing which includes body language. These factors help to achieve presence as a speaker and this presence is a must to public speakers in drawing the audience to what the speaker is talking about.

c. **Attitude and Demeanor**- "People may hear your words, but they feel your attitude." – John C. Maxwell. Convincing people and making them believe in your ideas is certainly not a cakewalk. But, by combining your positive attitude and confidence, you can build authentic and meaningful relationships with the audience and gain their trust. Further, if you have a positive attitude, your audience will also be positive and open to listening to your talk with full attention.

d. If you stay true to your missions and values, those who uphold the same will definitely connect with you in an organic way. The credibility that stems out from this trust helps you in the long run and keeps your audience coming back.

2. **Presentation and communication skills-** Communication skills are crucial for personal and professional success and improving this area is one of the greatest benefits of public speaking. Preparing a speech forces speakers to take a step back and think critically about effective ways to communicate. .

3. **Networking skills:**

Public speaking engagements are venues to meet other people who share the same interests. This is an opportunity or a springboard to connect to people since some people from the audience approach the speaker after the presentation to ask questions, clarify a point presented or simply engage in conversation. It makes it much easier to make new social connections. Try to mingle with the audience for as long as you can after your speech, answering questions and seeking fresh perspectives on your topic.

How does Public Speaking help in one's career?

A good speaker usually stands out in the workplace and has the respect of almost everyone there. Usually a good speaker initiates or is the first to speak up in meetings. In that scenario the speaker may sell his ideas, take the lead and present oneself as a professional employee. As a result, effective public speaking skills can help with career advancement, as they indicate creativity, critical thinking skills, leadership abilities, and professionalism, qualities which are very valuable for the job market.

People always remember a good public speaker and begin to see him as an authority in his line of expertise. Again, this is an opportunity in getting new client and business opportunities from people whose attention was captured by the speaker. All sorts of new business and speaking opportunities will open up as a result of a motivational or inspirational speech.

Words have power. The power to inform, persuade, educate, and even entertain are often embedded in words. The spoken word can even be more powerful than the written one if treated effectively by the right speaker. That is why speaking in public is imperative for businesses in marketing their products. Sales people and executives are always expected to have good communication and public speaking skills to be able to bring in more business to the company.

Speaking at events and conferences is a good way of building credibility. The more well known the event the better, as you can add these speaking achievements to your resume.

RECOMMENDED

Reading

Available on Amazon.com

ASSET MANAGEMENT DECISION-MAKING: THE **SALVO** PROCESS STRATEGIC ASSET: LIFE-CYCLE VALUE OPTIMIZATION

Edited by: John Woodhouse

A review by:
Dr. Wesam Beitelmal, CAMA
Assistant Professor
Dhofar University
wbeitelmal.du.edu.om

It will be an interesting trip that the book will take the readers who are enjoying discovering the asset management jungle. From the book's title SALVO, the authors wanted to emphasize their interest in decision-making with regards to assets and their management processes in all the asset life-cycle. It considers both program and portfolio levels.

By nature, the asset management processes will involve different stakeholders with different opinions. SALVO process will help managers and their companies to incorporate different perspectives into related decisions. Moreover, the SALVO process highlights how to identify the optimal time for both regular (minor) maintenance and the major maintenance and replacement cost. This will positively strengthen the companies' preparedness and negotiations with suppliers to reduce the costs of maintenance and purchasing spare parts by more than 50%.

In short, the first three chapters cover the basic information. For example, chapter 1 explains the scope and applicability of the book as a guide. Then, chapter 2 focuses on clarifying and defining the important concepts in asset management, especially the ones that will be used in the next chapters such as the link between decision-making and asset life-cycle, assets, strategies, risks, short and long terms, conflicts of interest, cost/risk, replacement decision, and optimization principles. Chapter 3 presents different decision support approaches and methodologies ending with discussing the SALVO processes and its framework! In general, companies can start using SALVO at different stages of an asset life-cycle and decision processes based on their needs as it is clarified in Chapter 4.

Chapter 5 gives the step-by-step as guide to implementing SALVO. It starts with identifying and prioritizing both problems and opportunities. It takes the reader through simple explanations and examples to emphasize important concepts: criticality and urgency of an asset. Then, define the problem starting with how to write the problem statement and reaching to discuss different analysis methods. Identify the possible solutions (actions) and results will be presented; then, possible actions will be evaluated by different methodologies and perspectives. Finally, optimization methods for the possible combinations of alternatives are explained and discussed to have the best life-cycle value from the assets that companies own and manage. Finally, aggregation for all the tasks/actions to be done will be grouped. Different funds will be present to consolidate programs/portfolios with costs, risks, resources, and time.

I encourage all of our practitioners and asset managers to have a look at the book and give us your feedback on our review and recommendation in general. Your opinion is very important for our continuous development. Please suggest a book to us that you feel will enhance the knowledge of our community in one of our important GSMR themes; meanwhile, you are also welcome to be a part of such column of the journal by participating with your review! Just take one step and contact us.

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