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The Challenges Achieving Compliance to RAGAGEP in Process Safety Management Enforcement and the Impact of Non-Compliance to Budget and Schedule

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Abstract

Every 5 to 8 years' large waves of capital spending occur known as MEGA Projects. These projects are effectively 1 or more Billion US dollars in Total Installed costs (TIC). When these projects are part of a global race to fill a void in the current marketplace, a serious race to be first to market or otherwise known as "Prime Mover" becomes the main driver and rapid deployment of resources. The reward for being the first to market is a higher (shorter) ROI (return on investment) cycle than other competitors and the ability to capture more customers than other competitors.

This paper will explore the challenges of being first to market and how that can affect meeting PHA/LOPA and ultimately achieving required SIL Targets and the impacts to costs and schedule.

Introduction:

Each year Owner/Operators and Engineering and Construction contractors meet the week following Labor Day at a Conference known as ECC. This year's ECC event was very much focused on the facts that in the world of heavy capital spending and MEGA Projects as a huge component of the overall capital spending yield significant failure rates in achieving their goals. The findings are:

- 98% of projects overrun both their budget and their schedule
- Budget overruns on average are 40%
- Schedule overruns are on average 20 months

As our Mary Kay O'Connor Process Safety Center sets the tone as a Center of Excellence around PSM and all those things under it, I found the fact that I was involved in several of these MEGA Projects and that in each of them there was an interesting and disturbing trend to assume that PSM needs were being handled as they should be, when in fact they were not.

There are reasons why the PSM needs were being compromised and we will discuss some of these discoveries in this paper as The Challenges to Meet "RAGAGEP".

Just what are the challenges faced in EPC/Owner executed projects from a PSM and DHS perspective

1. Getting the scope right from the beginning.

   Getting the scope right for Greenfield Capital projects from the beginning has become even more important than in previous times because of the tight timelines these projects must maintain and the proper use of investment funds being able to be more closely scrutinized in near real time metrics.

   More and more many of these multi-billion dollar investments are executed as Joint Ventures between interested parties and include external financing in many cases. The Jurisprudence aspect of properly forecasting the cash flow and returns on investment has never been as critical as it is in these highly volatile times. The net effect is this closer scrutiny stimulates an urgency to get to market on time or potentially miss the market window upon which you proposed the ROI. (Return On Investment)

   From and PSM (Process Safety Management) and constantly emerging DHS (Department of Homeland Security) set of standards/mandates owner-operators and detailed design contractors must be clear about the applicable regulatory requirements and the impacts of getting them wrong in the project gating processes even as early on as the conceptual phase.

   If the wrong assumptions about:
   - which parts of the project are mature enough to base the financial risk on
   - just how their timing in achieving the stated requirements is misunderstood
   - or critical requirements are simply overlooked due to a lack of understanding,

   the projects set themselves up for delays, extra costs and perhaps claims between partners and suppliers of malfeasance.

   (Definition -Malfeasance is bad behavior, especially from persons of authority who should know better.)

2. Additional Compliance with DHS impacts beyond conventional SIS

The addition of Cyber-Security risks to the other already known risks faced in numerous phases of a projects life-cycle make it important to know and follow the DHS needs starting in the conceptual phase and committing to the needs to protect the facility from cyber attached.

While this is important to all aspects of the facility it brings additional demands on the SIS (Safety Instrument System) design, almost returning prudent SIS designs back to the 1980's regiment of total separation via hardwired interfaces only, from any system that is connected to the internet. Web-based software updates and remote configuration invite hackers to the critical safety loops and even connectivity to lower level networks in a tradition four level network hierarchy are susceptible to hacks of the firewalls between them. Managing these risks out of a critical systems architecture are best managed by eliminating them to start with.
New versions of Stuxnet are being pioneered constantly and it is important to remember that the target of the Stuxnet virus was a SIL 3 Safety rated PLC.

The next steps in this regards is the merger of current ISA 84.01 and IEC 62443 Standards to effectively meet a global standard that can be used as "RAGAGEP" in our US 29 CFR OSHA 1910.119 statute for our Process Industries.

The merger of these standards are the way towards a release and targeted for release in either late 2016 or early 2017.

Currently only a few owner-operators are following the DHS cyber rules that got established in 2014. A few prominent owner-operators that produce highly volatile petrochemical and biological products have attempted to move ahead of having to play catchup by isolating critical systems such as Telecoms and SIS systems into a hardened environment that stops cyber intrusion from the beginning, i.e.…. practicing Situational Awareness in not inviting the uninvited in design to avoid the risk to start with. In this case old school segregation of critical functions and systems is the new hola-hoop.

Lessons Learned from Post 2010 Project Execution Phases

While the recent economic setback from the lower cost of various energy sectors is having another major impact in what we will eventually look back on as the 2014/2015 loss of oil revenues, the projects we are focusing our paper on are those projects that became part of the recovery post 2008 setback. These projects triggered the economic upswing of 2010/2011 benefiting from the cheaper feedstocks from the excess amounts of Shale Gas and various strategies around conversion of cheaper Ethane to Ethylene and their Derivatives products.

For the first time in decades' new major US capital projects funding to the tune of $70Bn worth became affordable and fed the downstream chemical industry in a US Chemical products wave of US world scale projects that financially support US Petrochemical production independence. This wave of new Petrochemical infrastructure and an

opportunity for increased market share dominance in the US plastics manufacturing industry became the turnaround of the 2008 setback.

These large Ethane-centric capital projects average between $5Bn to $11Bn, and are underway in a race to meet their business performance models that were used to obtain their FID (Funding Investment Decisions) in the first place.

While some are at lower risk than others due to specific reasons, in general they all have the following minimum deliverables that must flow out of the development gates that we in the Process Safety sector have the responsibility of helping mature.

The deliverables in any general gating process are simplified as follows:

- Conceptual Design / Pre-FEED
- FEED
- FEED Assurance or EWP (Early Work Projects)
- Detailed Engineering
- Construction.

It is rare that during the Conceptual/Pre-FEED stages for them to put much effort into assuring our PSM needs are thought through in any real detail, but as more and more emphasis on Proper Land Use comes into play, that situation will change.

Our paper is focused on the three project development phases that drive our PSM needs into the construction phases.

1. FEED (Level I PHA)

   FEED (Front End Engineering Development) generally anything from 6 months to 18 months in timeline development is the work post conceptual efforts to identify the overall process needs and other deliverables of a capital project. In each of the projects we know about, it is in this phase of work - sometimes done in competitive style of using more than one EPC think tank to against another to make sure fewer design anomalies might exist and the differences between these groups submittals can be compared to learn from and aid in assurances that a proper budget and primary process validation model has been developed.

   For us in the Process Safety sector the FEED key deliverables for all the process units and their ancillaries involved are:

   A. Level I PHA
   B. Risk Tolerance Matrix
   C. SRS (Safety Requirements Specification)
   D. Preliminary LOPA (Layers of Protection Analysis)
   E. IPL (Independent Protection Layer Analysis) based on PHA Level I Safeguard Assumptions

In 4 of the 6 shale gas spurred Ethane to Ethylene projects none of the deliverables above were developed to the proper stages before the FEED funds were exhausted or the FEED schedule forced an early cutoff to the FEED.

Of those 4 projects all have failed to meet their FID projections The only consistent deliverables made to base FID off of were items A and B above.

Unilaterally blind-eyes were turned to items C, D and E, which not only impacts the FID it majorly impacts the ROI business model as time to market is unable to be achieved in sequence with FID.

Further across the board – none of the ancillary packages whether they were from key licensors of guaranteed process performances, compression equipment suppliers etc.…. provided ISA S84/IEC 61508/61511 – "RAGAGEP" compliant solutions during the FEED stage.

On average there are 45+ such packaged units/sub-system units in these types of plants. Each of those packaged units/sub-system units required a PHA and the other deliverables listed as items A, C, D or E.

Since none of the supplier packages used to work up the FEED deliverables provided any of the key deliverables, PSM needs were missed entirely in the funding and scheduling studies produced in the FEED.

The chain reaction of this series of missed deliverables in some cases did not show up until detailed design level 3 PHA's and level 3 LOPA's.

In other instances, finishing that work became so out of sequence, work in those areas has been deferred until later and will become part of as built efforts, not an ideal scenario to train operations and maintenance personnel off of, or establish the best of life-cycle engineering work practices.

1. Early Works Projects (Level II PHA & LOPA I)

Since not all the missed deliverables in the FEED came from process safety gaps, several of the capital investors looked to what are commonly referred to Early Works Projects (EWP) which becomes a limited head start to Detailed Engineering done on a limited set of funding prior to full FID. These EWP's are using done by those one would want to award the Detailed Engineering to prime the pump for a rapid detailed engineering start. EWP's can when done well capture the gaps of a "lite" FEED, and are always expected to pay for themselves in reducing time to construction as the several month long EWP is used to establish terms, get commitments on schedules and budget and push the EWP EPC to a Lump Sum basis of award, pushing the financial and schedule risk off to the EPC.

During EWP activities our PSM deliverables are typically advancements to the same ones in FEED but at a minimum the target is to get to:

- ✓ Level III PHA that matches the refined P&ID's
- ✓ A next level LOPA based on the new safeguards discovered during the EWP activities.

So what do you think happens when the FEED work assumptions change and you didn't really due a LOPA in the first place?

The typical answer is we didn't know what we needed to know in the FEED and as expected the EWP activities have flagged up the new gaps we must take care of in the next phase. This excuse for not fully addressing prior to the start of the Detailed Engineering.

Providing the new discovery is progress but the reality is the EWP work is anywhere from 6 months to 12 months further down the project time line and so the failure to meet the scheduled activities for PSM sets the project up to having to compromise the advancements that support the start of Detailed Engineering and now other discipline work efforts such as piping, safe distances between equipment, proper egress in and out of the process units starts to move so far to the right of the FID schedule that shortcuts and promises of parallel activities being able to make up for this lost time.

Never forget that time is money, and when monetary limitations begin to be exceeded or are stretched, future activities get constrained and can begin putting pressure on dangerous comprises of prudent facility needs as priorities get reshuffled to hold budget.

Capital Projects use the FEED and EWP to validate what is known as Final Funding Approval, and so any of the deficiencies are either accounted for as project risk factors and contingencies to cover them get added to the overall budget or in as is the case in too many instances as looked at a cost and schedule reduction targets. Some Owner/Operators and EPC's would consider this a "rebase-lining" of the budget and schedule. Some would consider it the second bite at the cherry.

Cost pressure at this stage reaches a new focal point and if we didn't get our PSM needs into the budget by this time, they are subject to being ignored in the following stage of Detailed Engineering.

In each of the 4 affected projects, as FEED and Early Works activities wrapped up they were on average 3.5+ years into these 4 projects without maybe as much as 60% of the real PSM needs having been properly communicated or identified. Each of these projects found themselves running thin on acceptable reasons for more cost additions and under pressure to make-up for the lost time.

Remember the first 5 deliverables:

A. Level I PHA

B. Risk Tolerance Matrix
C. SRS (Safety Requirements Specification)
D. Preliminary LOPA (Layers of Protection Analysis)
E. IPL (Independent Protection Layer Analysis) based on PHA Level I Safeguard Assumptions

While various attempts at satisfying 1 thru 4 above, each of these projects ignored establishing IPL's (E) above in the early stages and the net result of that is the odds of having a semi worthy LOPA or a SRS sufficiently completed to issue meaningful orders for long lead SIS equipment hadn't even been addressed.

2. Detailed Engineering (Level III PHA & LOPA II +++)

So by now the theme of having shortcut and or missed several of our critical HSE/PSM deliverables to approach real needs prior to the Detailed Engineering start has been established in the A & B discussions preceding this phase of the gated work processes.

Hence the deliverables issued or not, going in to Detailed Engineering at best were derived from abbreviated or postponed efforts for the sake of time and money and now those omissions, bad assumptions and neglected activities in those previous phases all gets dumped on the Detailed Engineering task to sort out and or generate so late in the game.

The reality of having less HSE/PSM work in hand to be efficient and effective during Detailed Engineering puts an added burden upon what should or could have been the next steps towards completing (Phase III) PHA and LOPA activities.

Instead now the tasks have become concurrent attempts to complete the purposes of stepping stone activities all in the same time frame. This puts such an added burden on Management of Change that it stalls out the completion of the Detailed Engineering process, or leads to deferment of critical tasks and leaving them venerable to not being done at all.

As is evidenced by many of these projects having had to request additional funding, and issuing Press Releases to cover the set back to schedule and investors ROI, this is not an isolated occurrence.

The fact that the risk of budget shortages and schedule slippage get announced due to Truth in Lending regulations etc…. Sadly, that does not mean that the risk of missing PSM, EPA, DHS deliverables or personal safety targets ever gets revealed outside of the project teams themselves.

Since these projects are made up of various processes licensor packages and other key sub-systems, the need to communicate and harmonize all of the scope to one

consistent Risk Matrix from which all the other PSM alignment activities take place, the need to communicate that set of needs as early as possible is fairly obvious.

The unfortunate fact is this level of communication really doesn't occur until Detailed Engineering takes place as part of the challenge to these projects is spending as little as possible during the FEED and EWP segments of the facility's development.

It is important to capture the dichotomy between the concepts of "Time is Money" compared to "Money Well Spend".

Impacts

Each of the previously discussed postponed elements of scope development present the owner/operator, EPC and process licensor packages with an overflowing watershed of scope that must be brought back into balance.

The impacts from this set of late to be dealt with deliverables have unforgivable effects to Schedule and Budget and become new ROI threats in themselves.

1. Schedule
   Other than the simple and obvious shift to the right in schedule adherence, the compounding aspects of trying to meet RAGAGEP show up primarily as follows:

   - Out of Sequence Engineering Impact

     When schedule predecessors are ignored or postponed (deferred), the ability to properly move the project's requirements forward and it obstructs the ability to foresee or forecast accurately as to when the right succeeding activities and be finalized.

     The project finds itself in a 'Do-Loop" that only gets more exacerbating as less involved managers ask why it is a "circular reference" of sorts and the pressure on those executing the work becomes even more criticized than before taking the final resolution at ties further away from true closure.

     The pressure to torture the statistics to meet expectations worsens and a collaborative and cohesive engineering environment gradually decays.

   - Rework to Meet LOPA Risk Reduction Impact

In this phase of the project as well, the pressure to find or make up new LOPA/IPL angles to meet the needs to show RISK Reduction has reached maturity overnight, that new bad assumptions can surface, and the same aspects of the "Do-Loop" previously mentioned now hits at the heart of our PSM basics.

In this phase of things, I am proud to say real PSM and HSE individuals usually rise to the surface of there being no room for compromise, and a "HSE Re-baselining" event takes place as the project's ability to mask the bad assumptions that led it to this state of being get dealt with. Sadly, though the impact to the schedule is not reversible.

- Specialty Design Package Impact

It should come a no surprise that the LOPA/IPL voids in the specialty packages surfaces in the same time line as above and so finally the rework to third party packagers takes place.

The net result here is Management of Change sparks change orders to correct things to what they should be, and one of the inevitable sayings in the EPC industry comes into play in that "It is what it is". One of the reason this saying surfaces so late in the series of events is to take that approach too early in the life-cycle of the project would be deemed a "fait accompli" too soon.

- Average Schedule Slippage for the Ethane to Ethylene projects studied is 18 to 28 months beyond the approved FID Schedule. That translates to a slippage of approximately 35% on the range of 42 to 60 month schedules approved at FID.

2. Costs
    - "Time is Money" versus "Money Well Spent"

In the Early Phased Gates of FEED and EWP we touched on the fact that moving these phases forward quickly was important as the Final Funding Decision or Final Investment Funding (FID) is usually contingent on these two steps having been completed with some degree of certainty, in a perfect world that might be a +/- 10% definition of costs.

Parallel to this build up to FID is a constant market analysis study that balances the ROI based on just when products from these investments hit the market. Analysts reward or penalize the ROI depending on when

compared to demand for the products and against those the investment competes with.

Early ROI gets calculated in numerous ways but one of the compelling drivers of being early to finish and get to market first is a hedge against entering the market when it is saturation. Supply and Demand is an important consideration as an investor hones in on the "Rush, Walk or Stroll" to the finish line pace of investment.

In these examined projects around the Ethane to Ethylene expansions, being first to market at one time commanded a $1.2Bn ROI advantage. Being the "Prime Mover" is one of those such terms.

Obviously there can logically only be one 1st place winner, and that quest can unfortunately drive such a "Time is Money" set of blinders that it confuses the aspect of making sure one's investment achieves a "Money Well Spent" balancing act that really exists once the real accounting gets done.

- Missed Market Window Impacts on ROI.

So what happens when you miss being the "Prime Mover" or fail to get on the front end of "Supply and Demand" metrics?

The obvious answer is investors look to do further analysis as to why their expenditures failed to give them the assurances that convinced them to agree to FID in the first place. If the Investor/Owner/Operator is publicly traded it can be a wide swing in investor confidence problem that gets faced.

If you barrowed funds from banks, there will usually be an investigation as to has there been any "Malfeasance".

- The average value of financial overruns for the studied projects is 40%.

If We Really Learned from the Lessons these projects can teach us, We Would?

One needs to understand that just because a Lesson is observed and recorded, it isn't necessarily the same thing as the Lesson having been Learned.

A learned Lesson aspires to the goal of not being an error or anomaly that we fail to see happening to us the next time.

We would hope not to make the same mistakes twice if we really Learned our Lessons.

So what might be some quick HSE/PSM/EPA take away lessons from these studied projects to improve upon going forward?

3. Insist that FEED Deliverables include both Variable and Fixed Price Licensor and EPC Bid Packages that leading up to the FID trigger:
    - Meet the applicable PSM and Environmental Standards by Addressing:
        - ✓ PHA's and LOPA's Based on the Owner's Risk Tolerance Matrices
        - ✓ DHS Cyber Security Requirements
        - ✓ Approved Flare Permits
        - ✓ HSE Toxicology needs for both inside and outside the fence-line.
        - ✓ Responsible Community Planning inclusive of Land Management Best Practices

4. Insist that unless all above are fully dealt with prior to any Funding Investment Decision:
    - The FEED is incomplete and leaves the Owners and other investors at risk of:
        1. 40% over runs in costs
        2. 30% over runs in schedule
        3. Jeopardizing its business plans and goals for its shareholders., i.e... Impairing Financial Viability and ROI Metrics
5. Never allow pressures of schedule or price to take precedent over HSE/PSM/DHS or other prevailing Safety Factors and hold those who might attempt to compromise those needs opportunities to be properly developed in the sequence they need to be held personally accountable.
    - Every Person, Supplier and Subcontractor along the path of the project's deliverables and key decisions must all sign off on having been properly trained in the Safety Life-Cycle requirements under OHSA.

Summary - Our responsibilities to each other and those we serve…….

OSHA Process Safety Management (PSM) and EPA Risk Management Planning (RMP) are very detailed, complex regulations that apply to facilities using threshold amounts of highly hazardous chemicals. The complexity of these regulations, bring serious challenges to companies who elect to develop PSM and RMP programs in-house.

The challenge of incorporating the 14 elements established in the OSHA Process Safety Management standard, particularly with the recent changes due to reiterating the focus on

using Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) to develop Process Safety and Risk Management programs.

If we fail to properly manage and support the needs outlined and discussed in this paper, we set ourselves up to contribute to increased systematic failure rates due to the excessive pressure to reduce price over properly respecting and dealing with critical HSE risk factors.

Detecting, reporting, and responding to abnormal situations or events are all important functional elements of a complete process automation strategy. Traditional control systems present this information in the form of alarms directed to the operations staff on the control system console. In abnormal situations, the volume of these alarms floods can present a present a significant challenge as operators are subjected to too much information at once.

Process-related alarms are only one type of alert typically presented to the operations staff. For example, the growing importance of industrial control systems (ICS) cybersecurity means that security-related events must also be captured and managed.

The ISA/IEC 62443 series of standards on industrial automation and control systems security explicitly state that security-related events and alerts must be collected and maintained for analysis. The standards implicitly assume that once this information is collected, someone will be available to interpret it and take the appropriate action.

Automation solution providers and end users must focus not only on the nature of the information, but how to express it and, most importantly, to whom. More research and development is required in this area. End users must state clear requirements and expectations as to the types of in-formation they require when describing anomalous behavior in their processes.