REFINERY POWER OUTAGES: CAUSES, IMPACTS & SOLUTIONS

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OVERVIEW

• Major causes of refinery shutdowns
  – Electrical issues
• Impacts of refinery power outages
• Solutions to refinery power outages
  – Risk Management
  – Crisis Management
• RECOMMENDATIONS
CAUSES of REFINERY SHUTDOWNS

- From 2009-2014, there were 2837 reported unplanned shutdowns within US refineries
  - One fifth of Shutdowns are attributed to Electrical Issues

Unplanned Repairs & Maintenance 29%
Mechanical 40%
Other Problems 11%
Electrical 20%

CAUSES of REFINERY SHUTDOWNS (cont.)

• % breakdown of electrical shutdowns (US) 2009-2014
  - Over half of Shutdowns are related to Supply Losses/Power Surges

Accidents 1%
Fires 3%
Weather 12%
Supply Losses/Power Surges 55%
Equipment Failures 29%
POWER OUTAGE IMPACTS

- Financial Performance
- Plant Safety and Liability
- Negative Publicity
- Environmental Concerns and Penalties
- Energy Efficiency
POWER OUTAGE IMPACTS

• Financial Performance
  – Lost product from flaring
  – Loss of revenue for extended shutdowns
    • US Gulf Coast 80K b/b FCCU will lose $68K/day at refining margins of $1/bbl and 85% utilization rate
    • Losses will be greater at higher margins
  – Repair costs

• Energy Efficiency
  – Energy accounts for 43% of operating costs for US refiners
  – Motors consume twice as much energy during startup compared to normal operation
• Environmental concerns
  - Flaring of pollutant chemicals ($SO_x$, $NO_x$, aromatics, VOC, etc.)
  - Safety concerns for personnel & neighboring communities
  - Potential government intervention & fines
  - Need for flare monitoring & recovery equipment

- Visually unappealing to nearby residents
- Flaring accounts for 2.5% of CO$_2$ emissions (per US EPA)
POWERS OUTAGE \textbf{IMPACTS} (cont.)

\begin{itemize}
  \item \textbf{Plant safety and Liability}
    \begin{itemize}
      \item Poor operation of electrical equipment presents hazards
        \begin{itemize}
          \item Arc flashes, electric shock, fires
          \item Safety violations lead to fines from OSHA
          \item Lawsuits stem from workplace injury
        \end{itemize}
    \end{itemize}
  \item Environmental and safety issues create negative publicity for refineries
\end{itemize}
REFINERY POWER OUTAGE MITIGATION STRATEGIES

- Risk Management
  - Prevention and protection
  - Identify major causes of failures
  - Asset management
    - Preventive maintenance
    - Predictive maintenance
  - Emergency preparedness
  - Onsite generation

- Crisis Management
  - Salvage
  - Unit shutdown and restart
  - Backup power supply
  - Shutdown post-mortem
RISK MANAGEMENT

• **Prevention & Protection**
  – Compliance with national standards set by IEEE, NEMA, NFPA for electrical equipment
  – Understanding of internal and external factors that impact equipment reliability
    • Causes of equipment failures
    • Define specifications for electrical equipment to perform needed operational conditions and withstand major faults

• **Investment into protective equipment to isolate or absorb electric faults**
  
  *relays, circuit breakers, grounding equipment*

  - Must be capable of working in all possible fault conditions
  - Resistant to degradation over time to ensure reliability
RISK MANAGEMENT (cont.)

• **Identify major causes**
  - Quantification of particular problems within an industry
    - Shutdown database: [www.hydrocarbonpublishing.com/shutdown](http://www.hydrocarbonpublishing.com/shutdown)
  - Refiners should track internal issues and identify “problem children”

• **Emergency Preparedness**
  - Assessment of risks based on likelihood and consequence
    - Risk analysis matrix, layers of protection analysis (LOPA), process safety analysis
  - Understanding of emergency procedures in order to minimize loss & ensure safety
    - Unique for each unit within a refinery
  - Use of emergency response plans and communications (*both internal and external*)
Asset Management

- Getting the most out of a particular piece of equipment
  - Maximize effective running time
  - Minimize downtime/shutdowns

- Emphasis on maintenance strategy to extend running time
  - Studies suggest electrical equipment that is not under a maintenance program is three times more likely to fail
  - Planned shutdowns are always better than unplanned or “run till failure”
  - **Preventive maintenance**
    - Routine, thorough measurements to assess asset health
  - **Predictive maintenance**
    - Constant monitoring of key performance indicators (KPIs) for assets for early detection of impending failure
  - Effective communication between maintenance staff, plant operators, management
Onsite Power Generation

- Most effective means of shutdown prevention when power outages from third-party suppliers are common
  - Most times out of refiner’s control
- Cogeneration most common approach
  - Proven in refineries
  - High capital investment, long term economic benefits

Alternative energy and microgrids as potential future technologies

- Incorporation of solar, wind, CHP and third party to power a refinery
- Controls determine how much power is drawn from particular power source

All approaches bring added benefits beyond reliability

- Economic
- Environmental
Unit Shutdown and Restart
- Shift to mitigation measures to reduce downtime and loss
- Ensure safety and prevent further damage
- Load shedding to keep essential equipment online
- Clear and concise shutdown and restart procedures must be well defined and carried out
- Total shutdown vs. reduction in capacity

Backup Power Supply
- Backup generators, uninterruptible power supply (UPS)
- Adds redundancy to electric system
- Temporary solution while original power source recovers
- This equipment also must undergo effective asset management
• **Shutdown postmortem**
  – Learning from past mistakes
  – Root cause failure analysis (RCFA)
    • Incorporates knowledge of many technical fields
    • Data availability is vital for RCFA’s effectiveness
    •Shutdowns often the outcome of multiple cascading factors
    • Discover underlying causes of power failures and unwanted shutdowns

• **Salvage**
  – Economic option for damaged equipment
  – Some equipment is damaged beyond repair
  – Saves capital costs on replacement equipment
**RECOMMENDATIONS**

- **Understand the Risks!**
  - Know the consequences of power failure
    - Financial loss, environmental concerns, energy efficiency, safety, public image
    - Know how to prevent the loss or minimize the impact
  - Gain knowledge of the underlying causes of power outages
    - Both within a particular refinery and throughout the industry
    - Knowing the common causes helps identify the best course of action
RECOMMENDATIONS (cont.)

• **RISK MANAGEMENT**
  – Find best solutions that eliminate or reduce the likelihood of power failure
  – Can be technological or procedural solutions
  – Keep in contact with equipment vendors to determine ideal operational and maintenance strategies
  – Consider onsite generation to decrease dependence on third-party energy suppliers

• **CRISIS MANAGEMENT**
  – Ways to properly respond to power failure
  – Minimize financial loss, flaring and overall downtime

• **Know the additional benefits of changes or upgrades**
  – Simultaneously improve efficiency, cut operating costs, lower emissions, and reduce carbon footprint
Important Topics Covered:
- Emergency preparedness & experiences
- Prevention and protection
- Recovery, restart, and salvage
- Electrical equipment reliability improvements
- Safety management
- Maintenance advances & asset management
- Onsite power generation (CHP, renewable energy, microgrids)

Power outage causes
- 1 out of 5 refinery shutdowns!

 Millions of dollars lost from
- missed production
- excessive flaring
- unsafe operations
- legal liabilities

www.hydrocarbonpublishing.com/power