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# PERFORMANCE INDICATORS FOR RESEARCH REACTORS

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# Performance
# What does it mean?

- Measuring how an activity is done
- Success or Failure
- Doing your best
- Living up to expectations
- “Going the extra mile”
- Receiving an ovation

- Winning the U/11B football (soccer) premiership
- Safe and well utilised facility

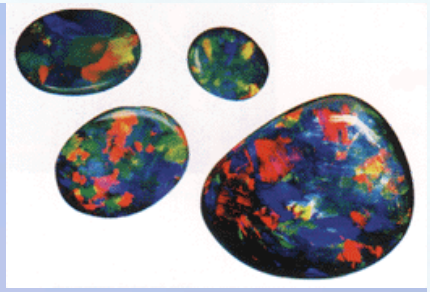
# Measuring Performance

- Winning
- How you played
- Personal best
- Team success

- Quantitative demonstration of success factors in a business

- U11Bs won 3-1in the Grand Final

# OPAL



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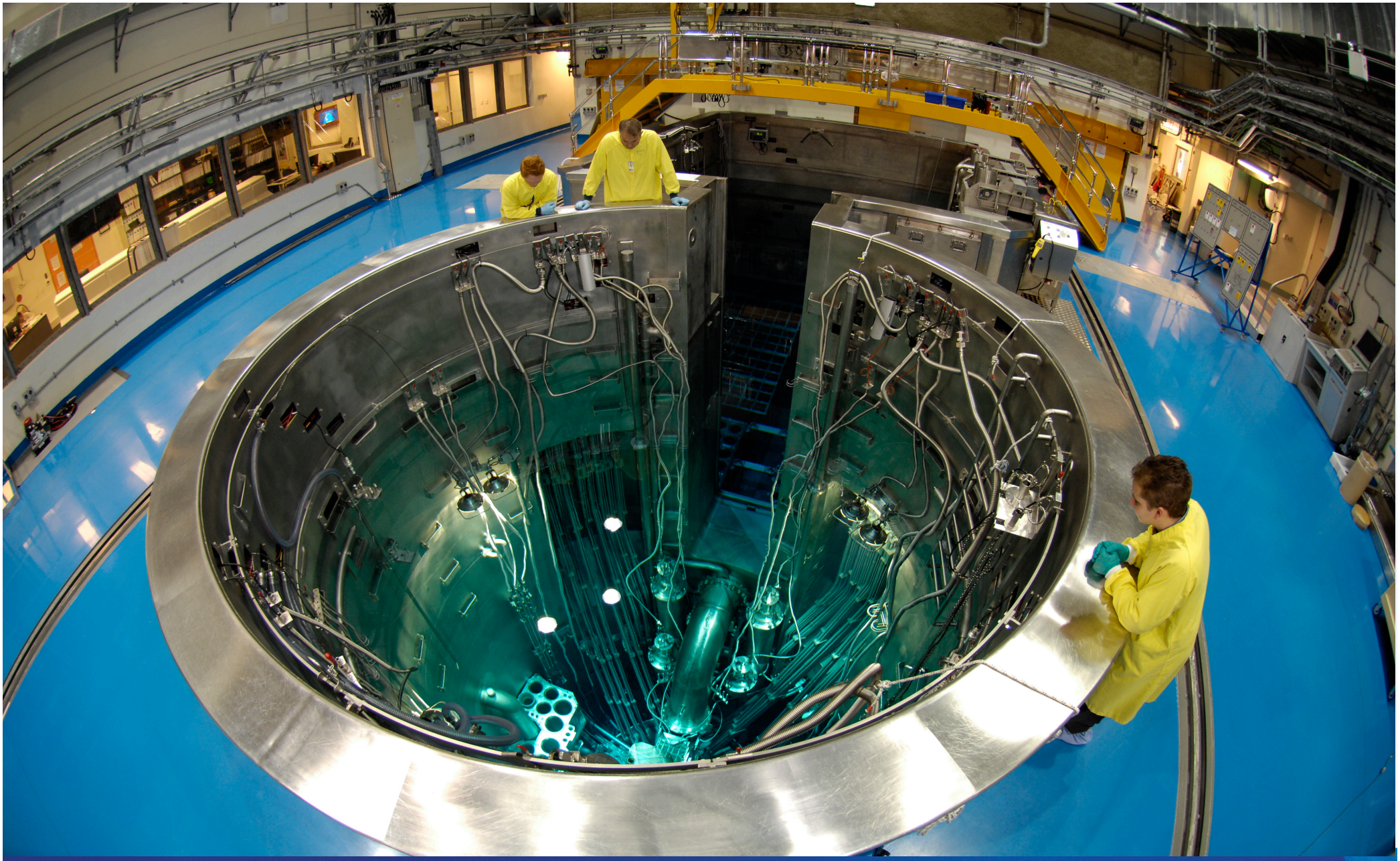

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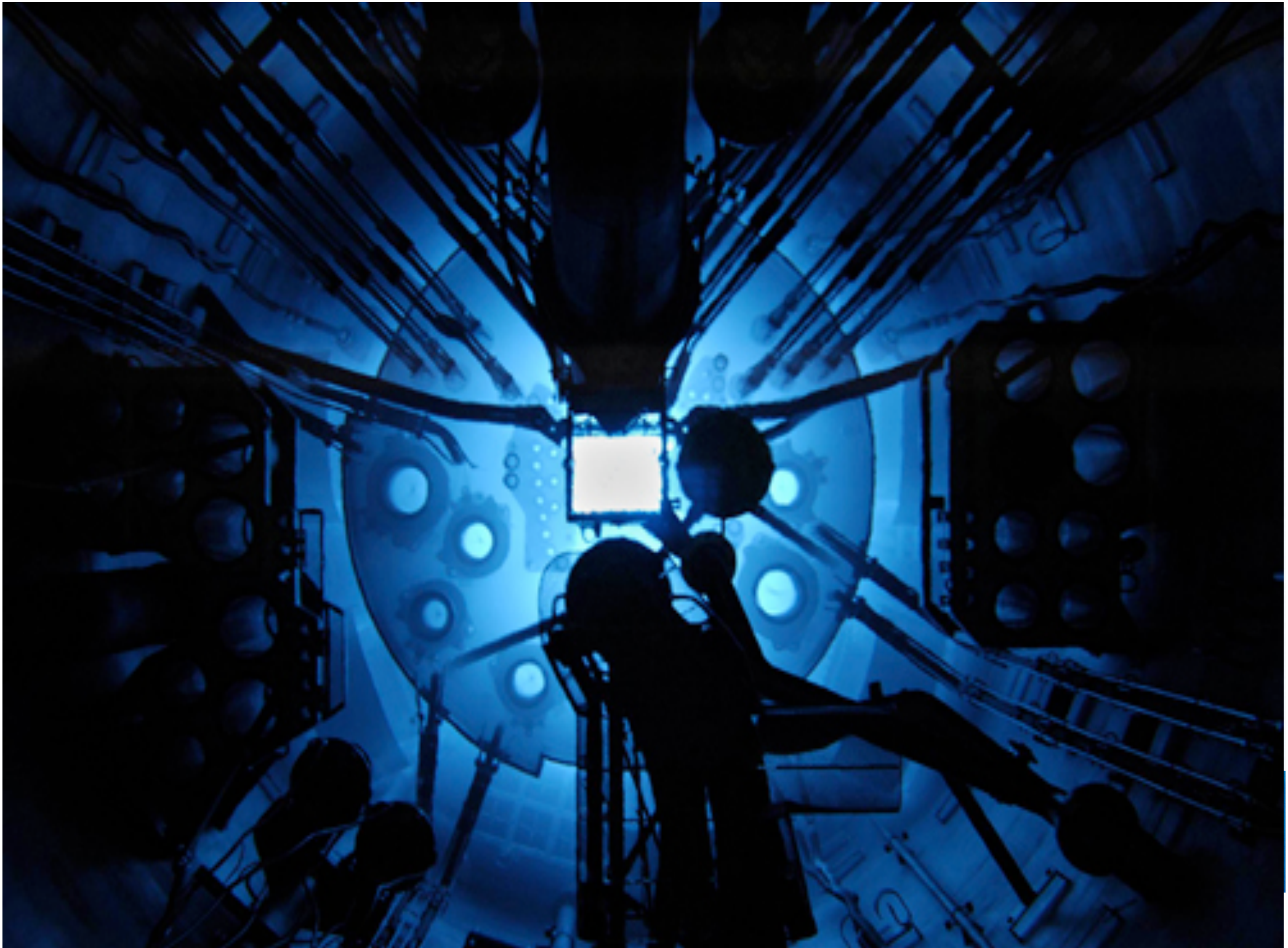
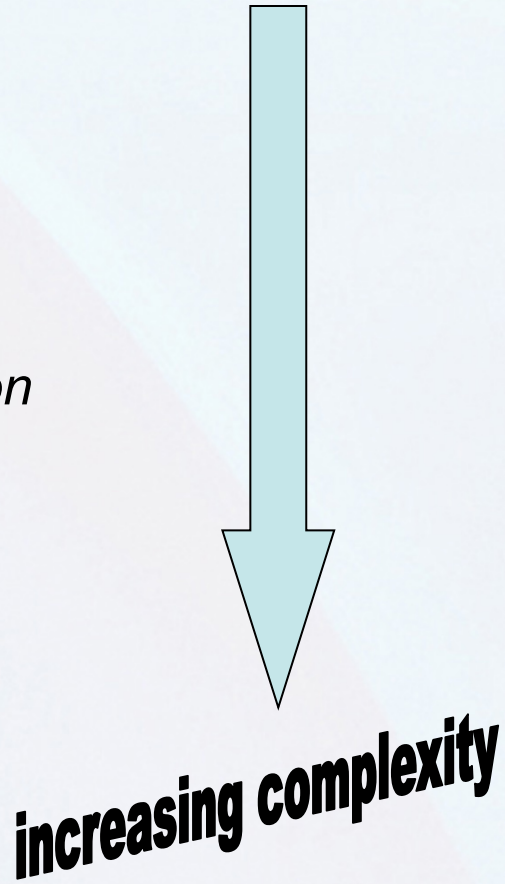


# Performance at OPAL

- **Project**
  *Cost, Schedule, Licensing, Commissioning*
- **Operation**
  *Commissioning, Availability, Reliability, Utilisation*
- **Safety**
  *Safety Performance Indicators*
- **Culture**
  *Culture Survey, Attitudes, Behaviours*



# Safety Performance Indicators (SPIs)

- SPIs – from Nuclear Power Plant Safety Events
  *TMI, Chernobyl → drove regulation to performance measurement*

- OPAL Operating Licence Condition
  *Develop a set of SPIs to satisfaction of the CEO of ARPANSA*

- Reference to CNRA/CSNI, IAEA, WANO
  *NPP based*

***Research Reactors – guidance in this area not well developed***

# Guidance on Safety Performance

- RRs are disparate in design, usage
- Difficult to generalise
- Standardising unlikely
- Benchmarking is possible
- International meetings and collaborations
- Research Reactor Code of Conduct

U11B CPR were beaten twice in the season by Kogarah Waratahs

# OPAL SPIs - Approach

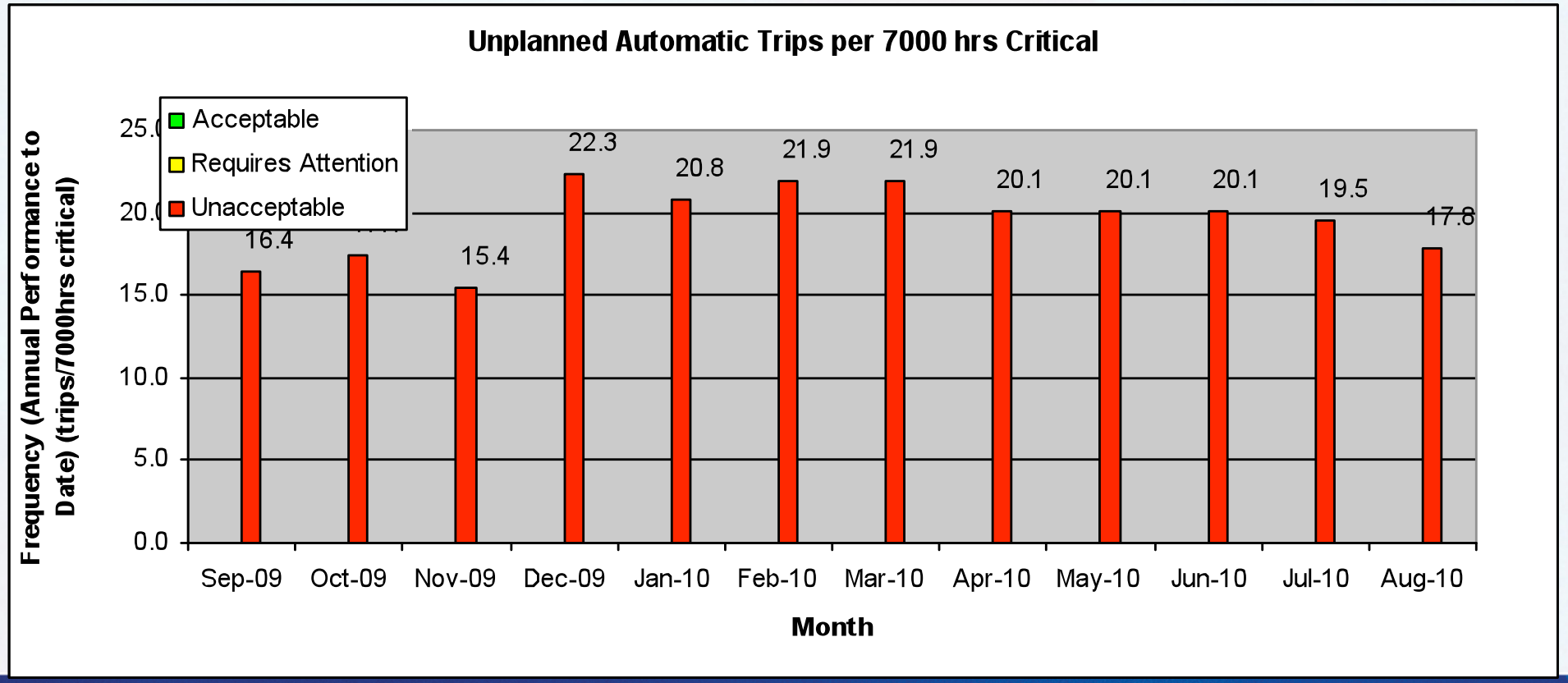
- SPIs form part of a safety management system
- Considering a range of indicators will lead to insight
- Early warning for deterioration in performance
- Targets – focus attention to drive improvement
- Benchmark – international comparison

# OPAL SPIs – attributes & areas

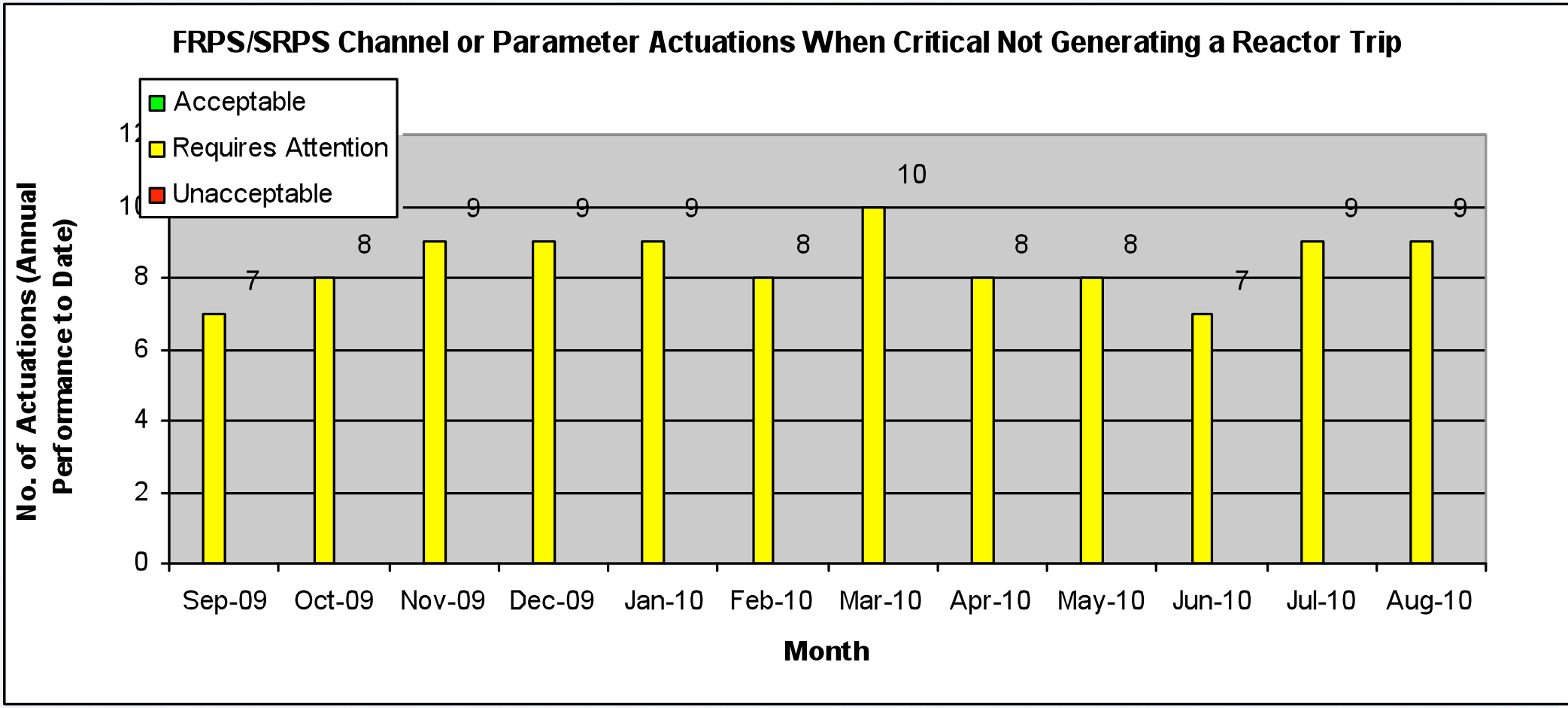
- Clear definition
- Easily understood
- Timely indication of safety degradation
- Reporting period allows timely corrections

- REACTOR SAFETY
- RADIATION SAFETY
- INDUSTRIAL SAFETY
- SAFETY MANAGEMENT

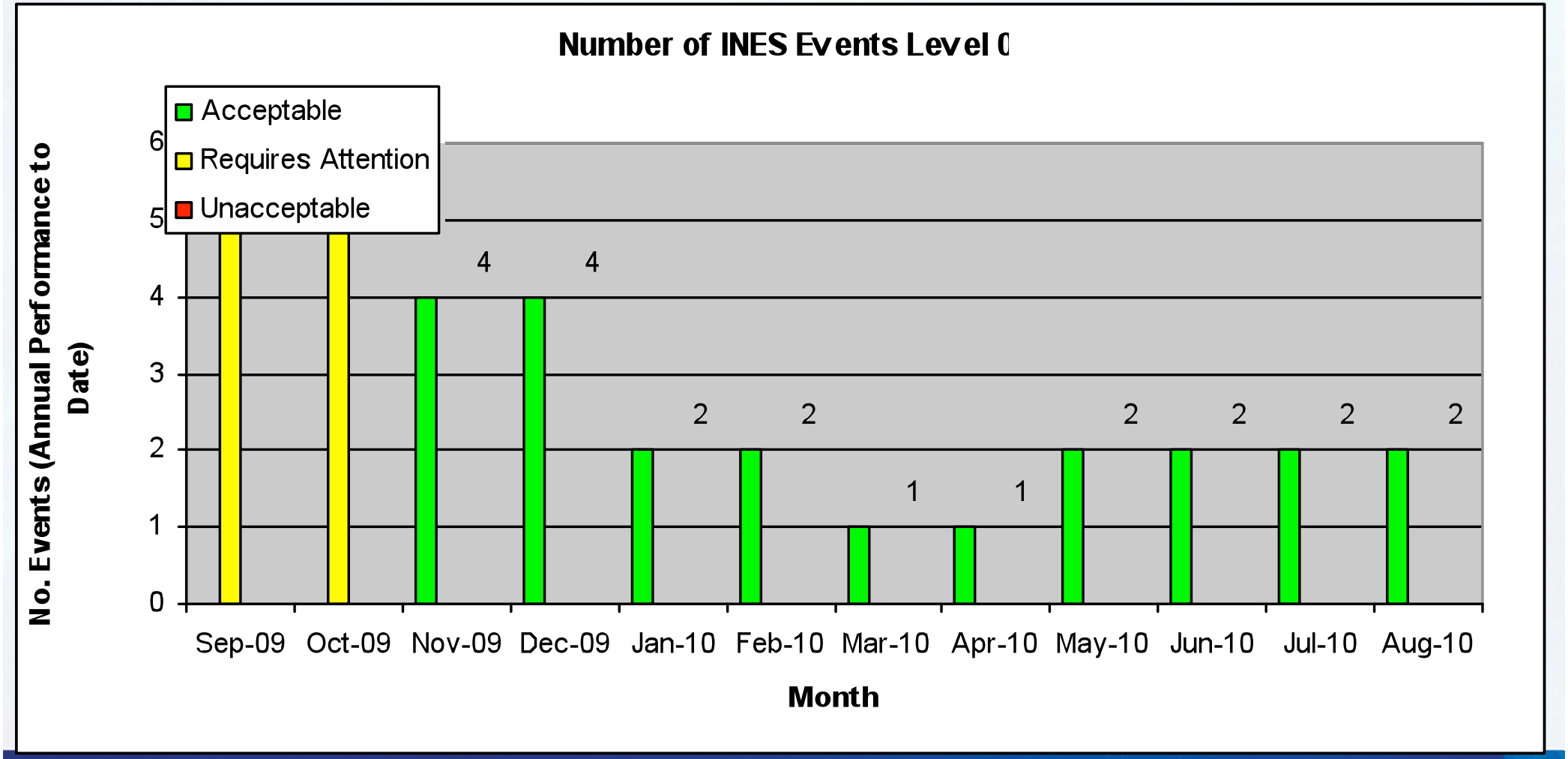
# Unplanned Trips



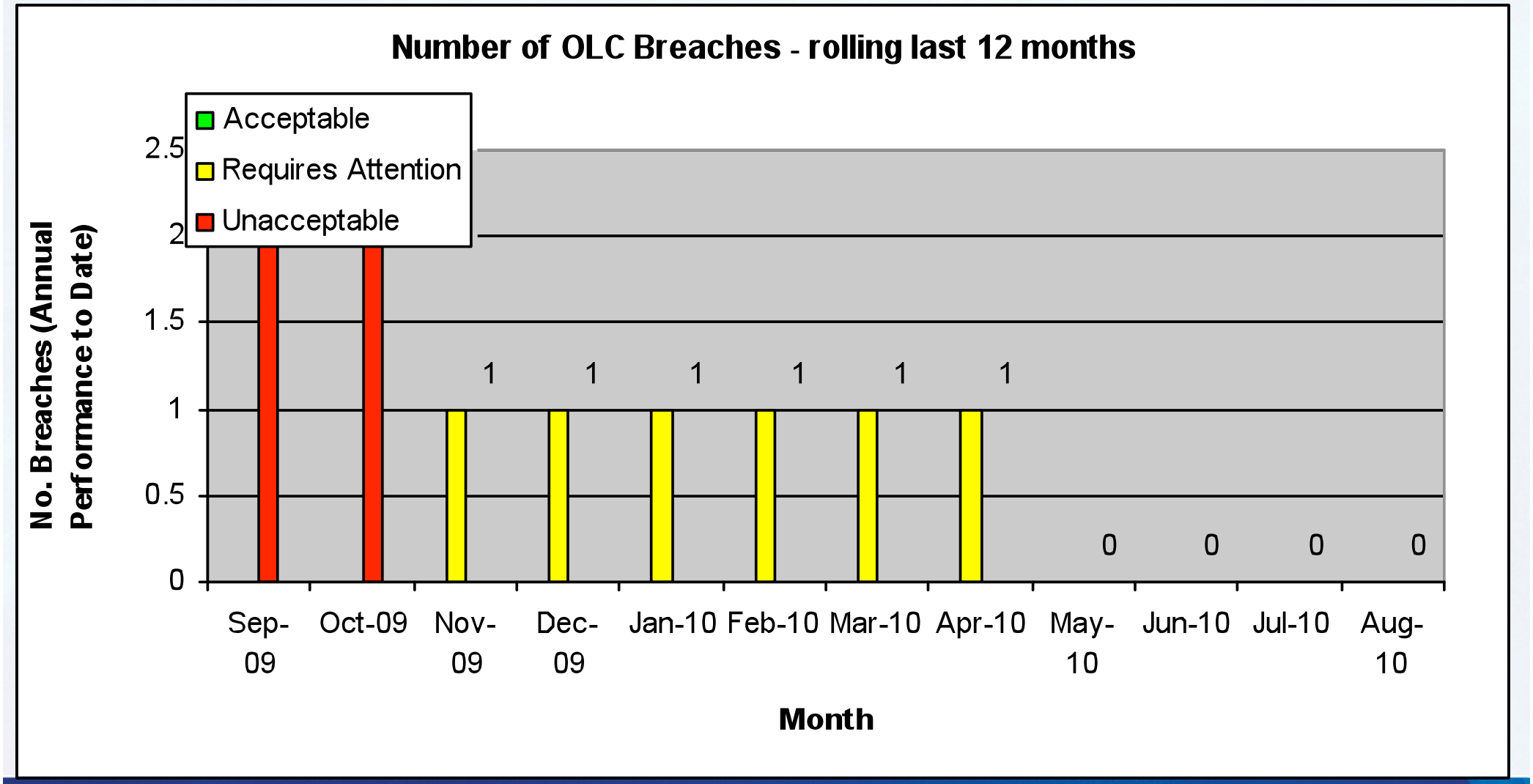
# Protection System



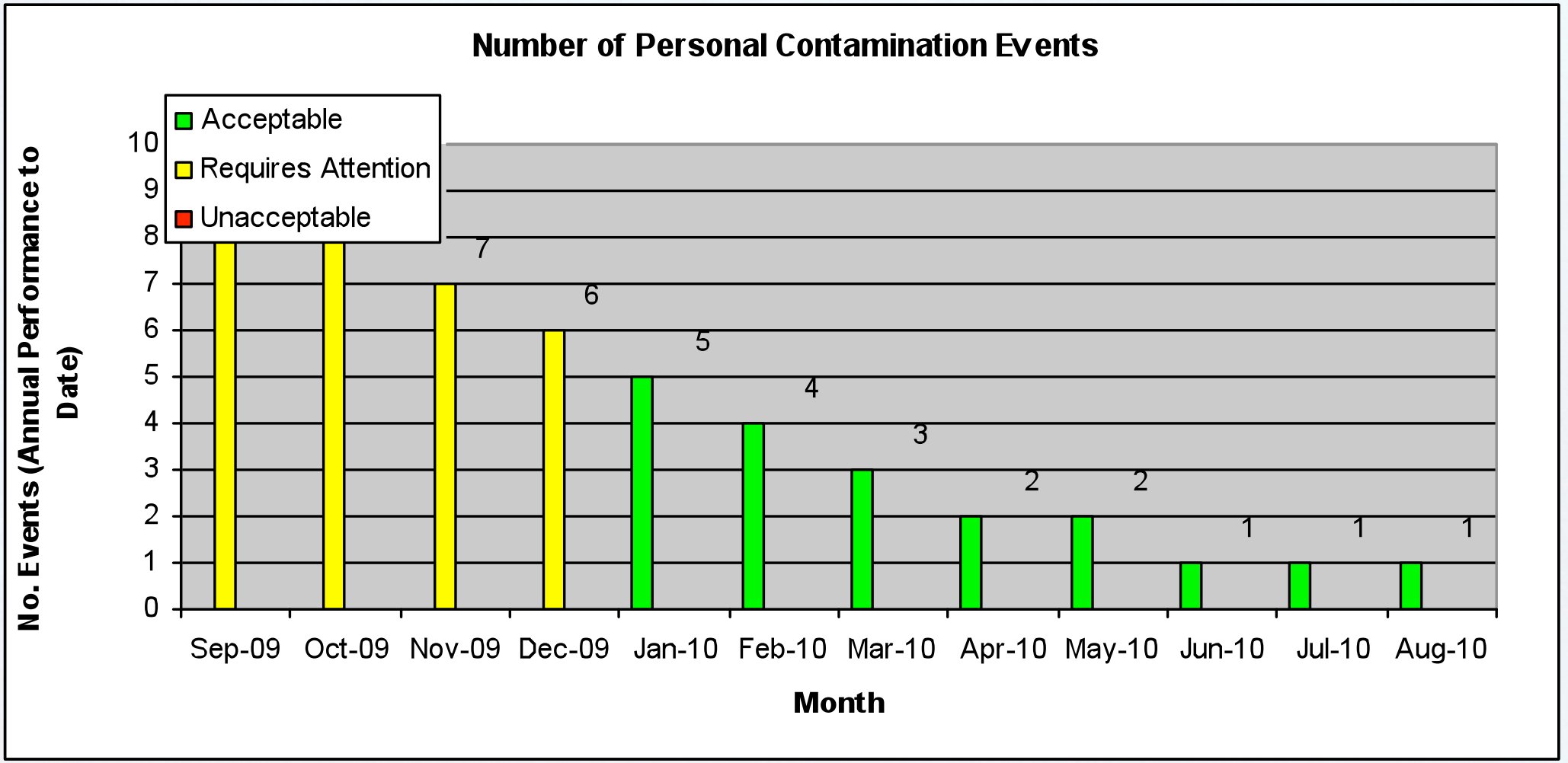
# INES Level


Number of INES Events Level 0
Acceptable
Requires Attention
Unacceptable
No. Events (Annual Performance to Date)
0
1
2
3
4
5
6
4
4
2
2
1
1
2
2
2
2
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Month

# OLC breaches



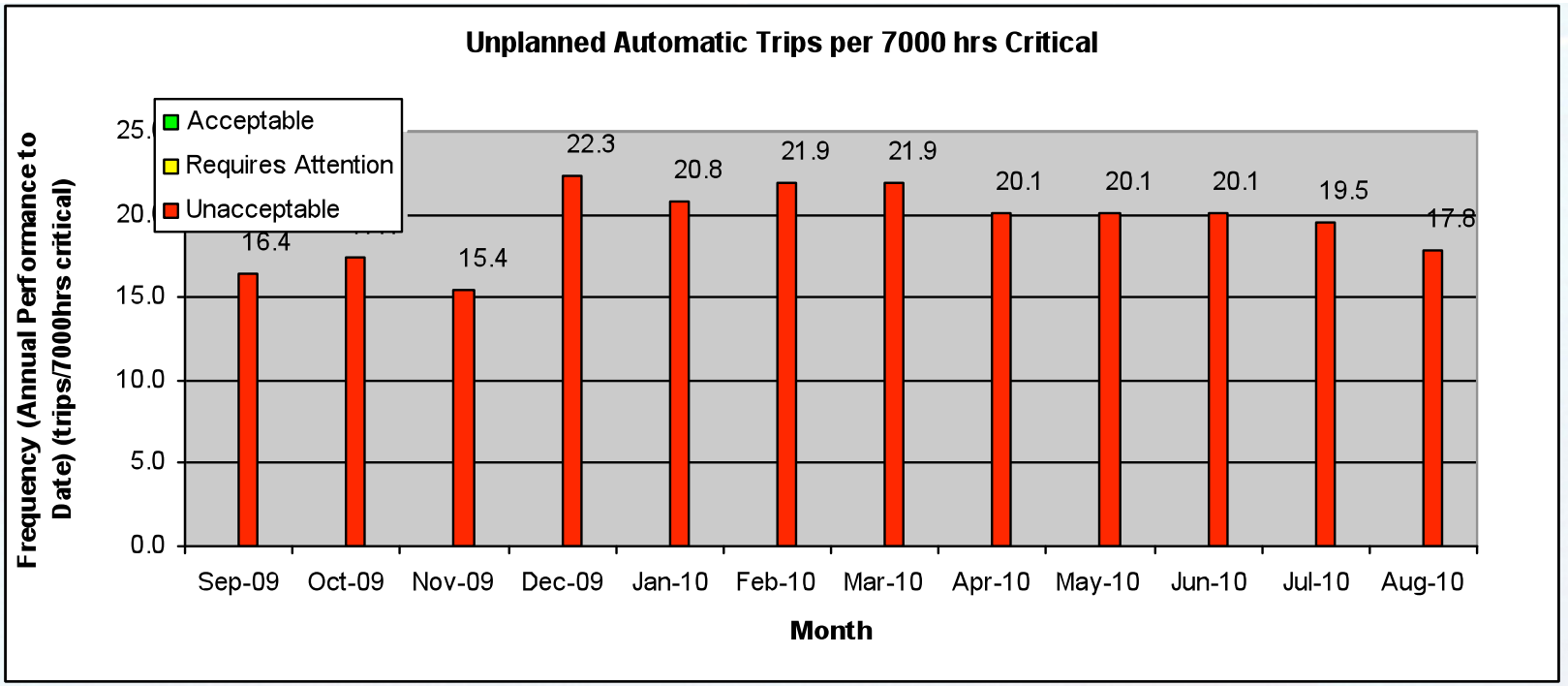
# Staff contamination

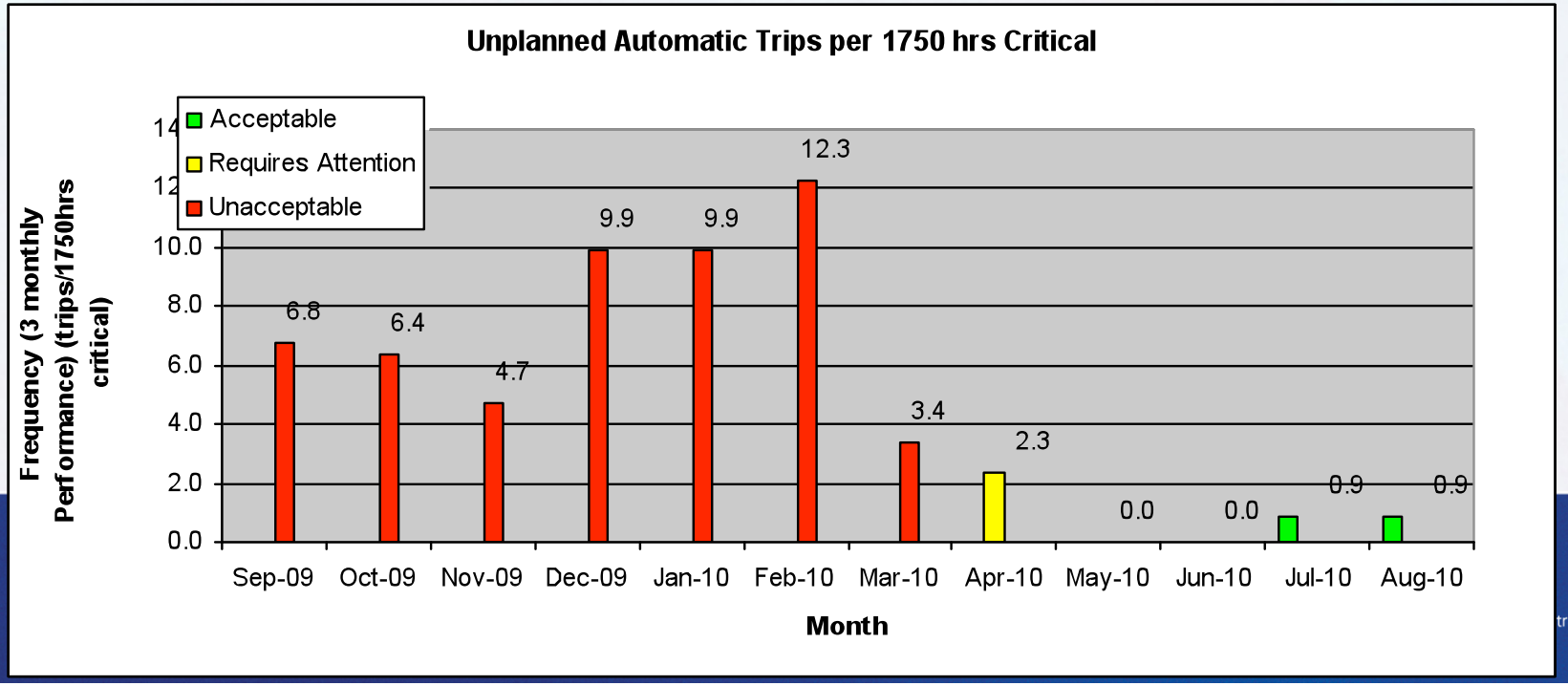


| Safety Performance Indicator | Annual Goal | May 10 | June 10 | July 10 |
|---|---|---|---|---|
| Unplanned automatic trips per 7000 hrs critical | 6 | 20.1 | 19.5 | 17.8 |
| Number of FRPS/SRPS actuations when critical not generating a reactor trip, rolling last 12 months | 6 | 7 | 9 | 9.0 |
| Number of reportable events INES > 0, rolling last 12 months | 0 | 1 | 1 | 1 |
| Number of INES events level 0, rolling last 12 months | 4 | 2 | 2 | 2 |
| Number of INES level 0 or >0 with Human Factor as a principal cause rolling last 12 months | 1 | 0.3 | 0.3 | 0.3 |
| Number of OLC breaches, rolling last 12 months | 0 | 0 | 0 | 0 |
| Number of unplanned times a limiting condition entered, rolling last 12 months | 12 | 30 | 32 | 29 |
| Number of times unavailability detected during OLC SR, rolling last 12 months | 3 | 10 | 10 | 9 |
| Maximum monthly PCS coolant activity (μSv/hr) | 1500 | 961 | 1155 | 1903 |
| Maximum individual effective dose mSv/yr, rolling last 12 months | <2 | 1.4 | 1.4 | 1.4 |
| Number of staff with annual dose exceeding 5mSv, rolling last 12 months | 0 | 0 | 0 | 0.0 |
| Number of staff with annual dose exceeding 2mSv, rolling last 12 months | 2 | 0 | 0 | 0.0 |
| Number of dose investigations required, rolling last 12 months | 0 | 0 | 0 | 0.0 |
| Number of personal contamination events, rolling last 12 months | <5 | 1 | 1 | 1 |
| Number of Actual Fires, rolling last 12 months | 0 | 1 | 1 | 1 |
| Number of Lost Time Injuries, rolling last 12 months | 0 | 3 | 3 | 3 |
| Number of internal BMS audits not completed to schedule. | 0 | 0 | 0 | 0 |
| Number of corrective actions from external Quality/environment audits outstanding after 3 months | 0 | 0 | 0 | 0 |
| Number of staff accredited for the control of reactor operations - minimum each month | >15 | 23 | 22 | 21 |
| Percentage of Cat 1 and Cat 2 maintenance plans in compliance | 90 | 85 | 85 | 83 |
| Percentage of housekeeping inspections completed to schedule (%) | 100 | 93.5 | 88.5 | 88 |
| Percentage of event reports open 1 month after event (%) | 25 | 32 | 34 | 34 |

# OPAL SPIs - outcomes

- Using SPIs for about 2 years
- Overall SPIs have been useful
- Some SPIs may require redefinition
- Some targets may need to be reset
- “Leading” indicators required
- Possible change to 12 month rolling basis
- Review conducted by Nuclear Regulator
- More maintenance related indicators


Unplanned Automatic Trips per 7000 hrs Critical
Acceptable
Requires Attention
Unacceptable
Frequency (Annual Performance to Date) (trips/7000hrs critical)
25.
20.
15.0
10.0
5.0
0.0
16.4
15.4
22.3
20.8
21.9
21.9
20.1
20.1
20.1
19.5
17.8
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Month


Unplanned Automatic Trips per 1750 hrs Critical
Acceptable
Requires Attention
Unacceptable
Frequency (3 monthly Performance) (trips/1750hrs critical)
14
12
10.0
8.0
6.0
4.0
2.0
0.0
6.8
6.4
4.7
9.9
9.9
12.3
3.4
2.3
0.0
0.0
0.9
0.9
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Month

# Leading indicators

- AECL – 7 leading and 7 lagging indicators
- Leading indicators
  - Self-assessments, Work Permit compliance
  - Observation and coaching,
  - Safety related system surveillance, Housekeeping tours

- Safety research* – cause/consequence relationship may not be adequately captured
- Activities and Outcomes based indicators may be a better way to define#

- ** A. Hopkins, L. Harms-Righdhal, both in Safety science Vol 47, 2009*
- *# OECD, Guide on Safety Performance Indicators, 2003*

# Other indicators

- Variety of inputs and trending needed in an integrated management system to improve performance
- Investigations required to understand the nature of events and the underlying safety trends
- Operational performance

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# ONF 005
# OPAL Reactor Cycle Summary

| Operating Cycle | 024 | from | 28/06/2010 | to | 08/08/2010 |
|---|---|---|---|---|---|

| Operating Cycle Data | |
|---|---|
| Total days in cycle | 41 |
| Targeted EFPD | 33 |
| Scheduled days at power | 36.13 |
| Date of refuelling | 02/07/2010 |
| Time of reactor start-up (first critical) | 03/07/2010 12:33 AM |
| Time of reactor shutdown | 08/08/2010 3:03 AM |
| Average power | 18.19 MW |
| Average heavy water purity | 97.8 % |

**Days Operating**

| | Cycle | Calendar year | Overall |
|---|---|---|---|
| Days at power | 34.5 | 177 | 686 |
| EFPD | 31.4 | 160 | 611 |

**Reactor Availability**

| | Cycle | Calendar year | Last 12 Months |
|---|---|---|---|
| Overall availability | 84 % | 81 % | 76 % |
| Planned availability | 96 % | 96 % | 96 % |
| Reliability | 96 % | 96 % | 96 % |

**Cold Neutron Source Availability**

| | Cycle | Calendar year | Last 12 Months |
|---|---|---|---|
| Availability at power | 100 % | 83 % | 69 % |

| Irradiations | |
|---|---|
| Uranium plate irradiations | 104 plates (13 rigs) |
| Tellurium Dioxide targets | 7 |
| Samarium Oxide targets | 6 |
| Chromium targets | 4 |
| Other LRT targets | 25 |
| DNAA targets | 448 |
| NAA targets | 47 |
| NTD silicon arrays | 172 |
| Total irradiations | 813 |

**Operational History**

| | |
|---|---|
| Cycle summary | Cycle 24 commenced on Monday 28th June 2010 with a maintenance and refuelling period. The reactor returned to nominal full power on Saturday 3rd July 2010 at approximately 0130hrs.<br>Operation continued until Wednesday 14th July at which time the reactor was automatically shutdown at 0334hrs due to an off site electrical power disturbance. As a result of the power disturbance the Cold Neutron Source faulted and reactor restart was inhibited. The CNS fault was rectified and the reactor returned to nominal full power at 1847hrs on Thursday 15th July 2010. Operation continued until the end of the cycle. |
| Unscheduled shutdowns | 1 |

**OPAL Reactor Cycle Summary Completion**

| Action | Name | Position | Signature | Date |
|---|---|---|---|---|
| Prepared by | Rodney Hall | Nuclear Analyst | | 23/08/2010 |
| Checked by | George Braoudakis | Leader, Nuclear Analysis Section | | 23/08/10 |
| Approved by | David Vittorio | OPAL Reactor Manager | | 23/8/10 |

# Other indicators

- Risk-based performance indicators
- Qualitative cultural indicators – monitoring & tracking problematic
- Using PSAs for NPPs
- Model
  - Initiating events
  - Reliability of systems, trains, components
  - Mitigation potential of engineering systems
  - Mitigation potential of emergency actions
- Indicators impacting (a) hardware (b) personnel
- Review event reports & review reliability data*

** S. Chakraborty et.al. Risk based Safety Performance Indicators for Nuclear Power Plants, SmiRT, 2003*

# The Future

- OPAL – workshop with Nuclear Regulator – review and improve
- Staff engagement and input
- Discuss with other operators the possibility of a defined set of PIs for Research Reactors
- Investigate whether the Research Reactor Code of Conduct could be used as a vehicle for this

# CONCLUSION

- **Why did the CPR U11Bs perform so well?**

Excellent training and coach
Cohesive team
Supportive club

Train and develop staff
Build a culture that is aligned
Management are supportive


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