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PERFORMANCE INDICATORS FOR RESEARCH REACTORS

Greg Storr & Mark Summerfield

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

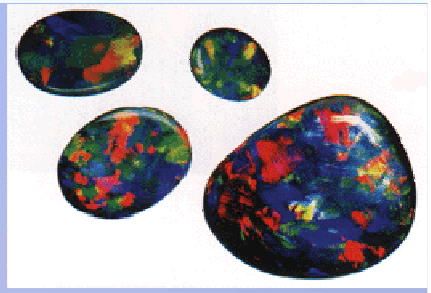
Measuring Performance

- 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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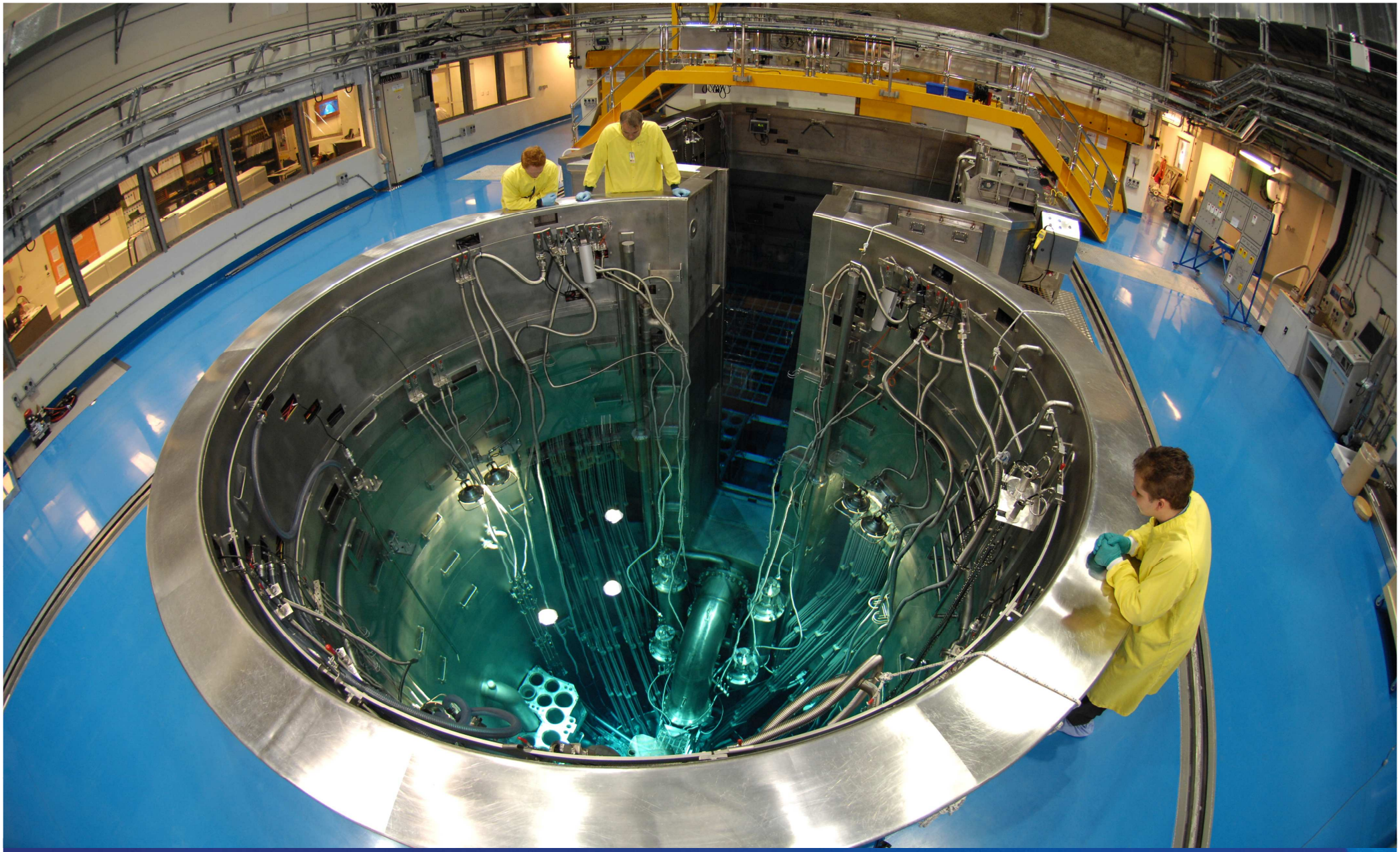

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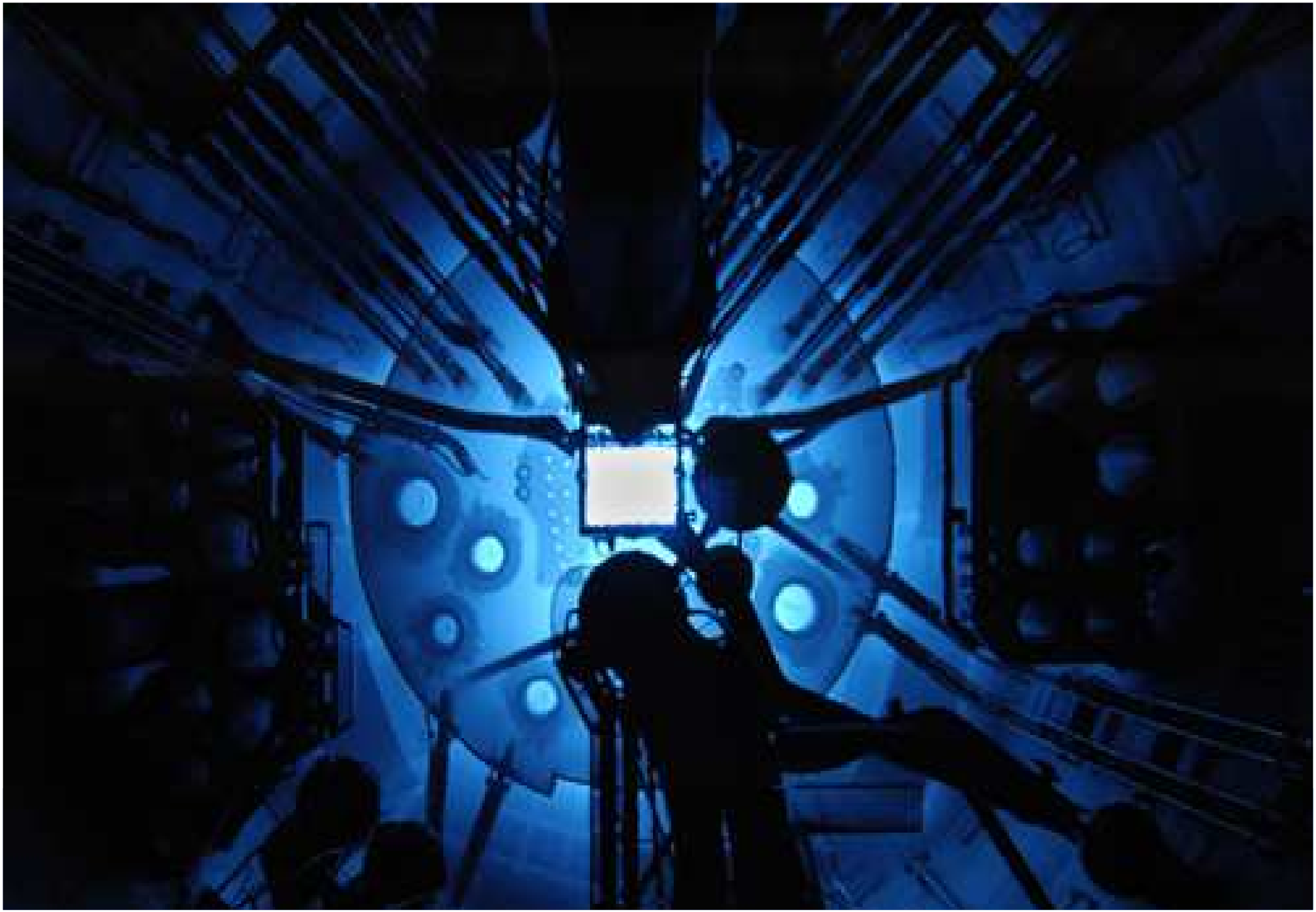


Performance at OPAL

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

increasing complexity

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
- 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

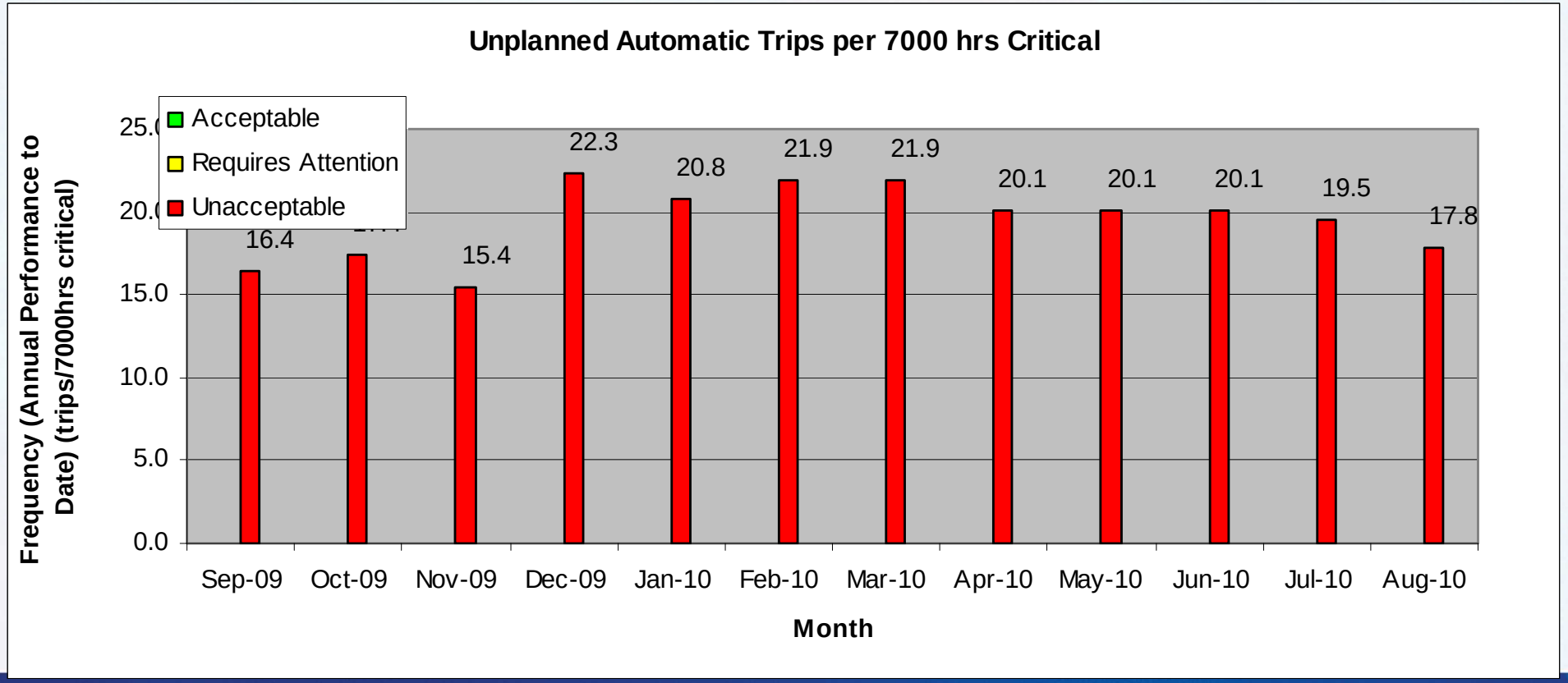
- SPIs form part of a safety management system
- Considering a range of indicators will lead to insight
- Early warning for deterioration in performance
- Targets – focus attention to drive improvement
- Benchmark – international comparison

OPAL SPIs – attributes & areas

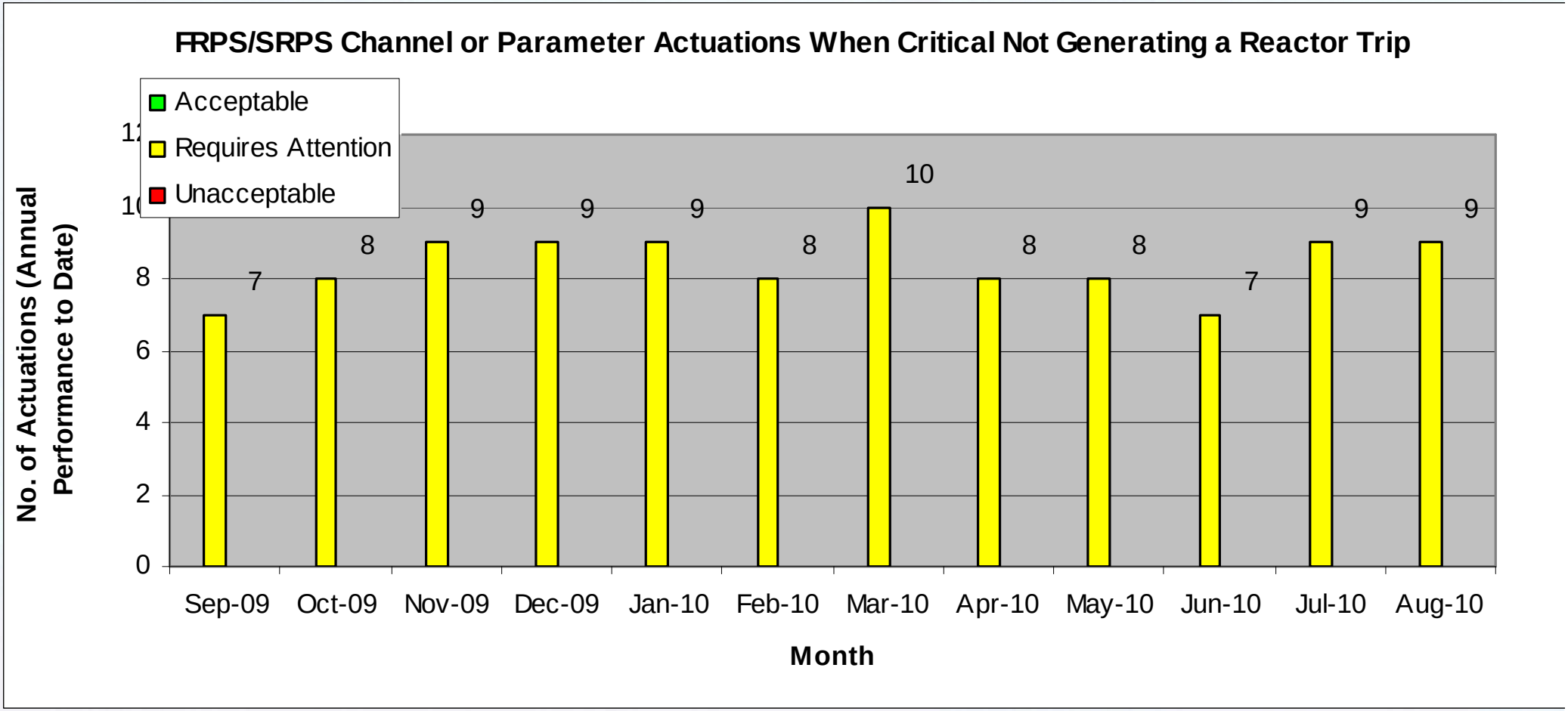
- Clear definition
- Easily understood
- Timely indication of safety degradation
- Reporting period allows timely corrections

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

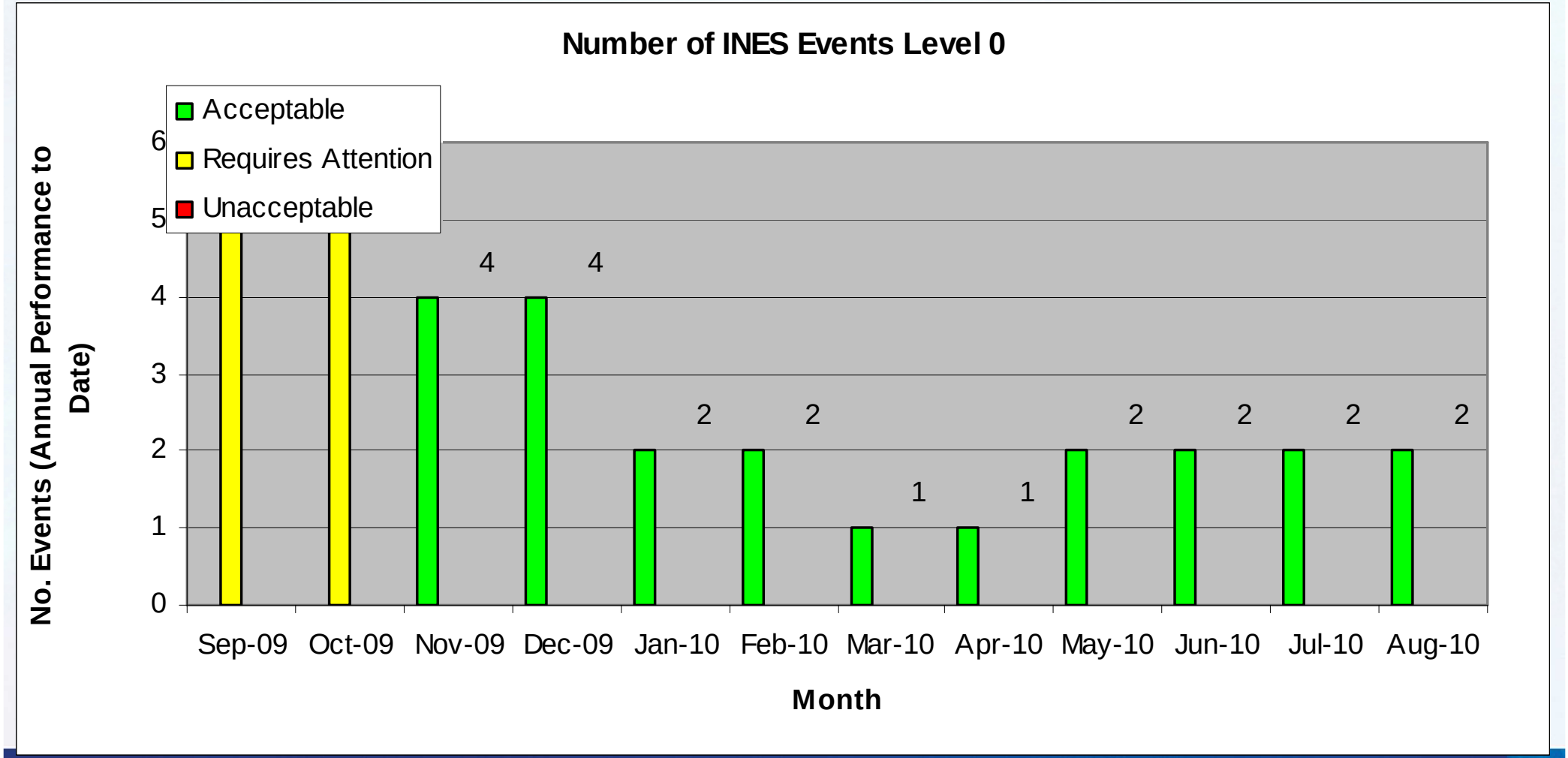
Unplanned Trips



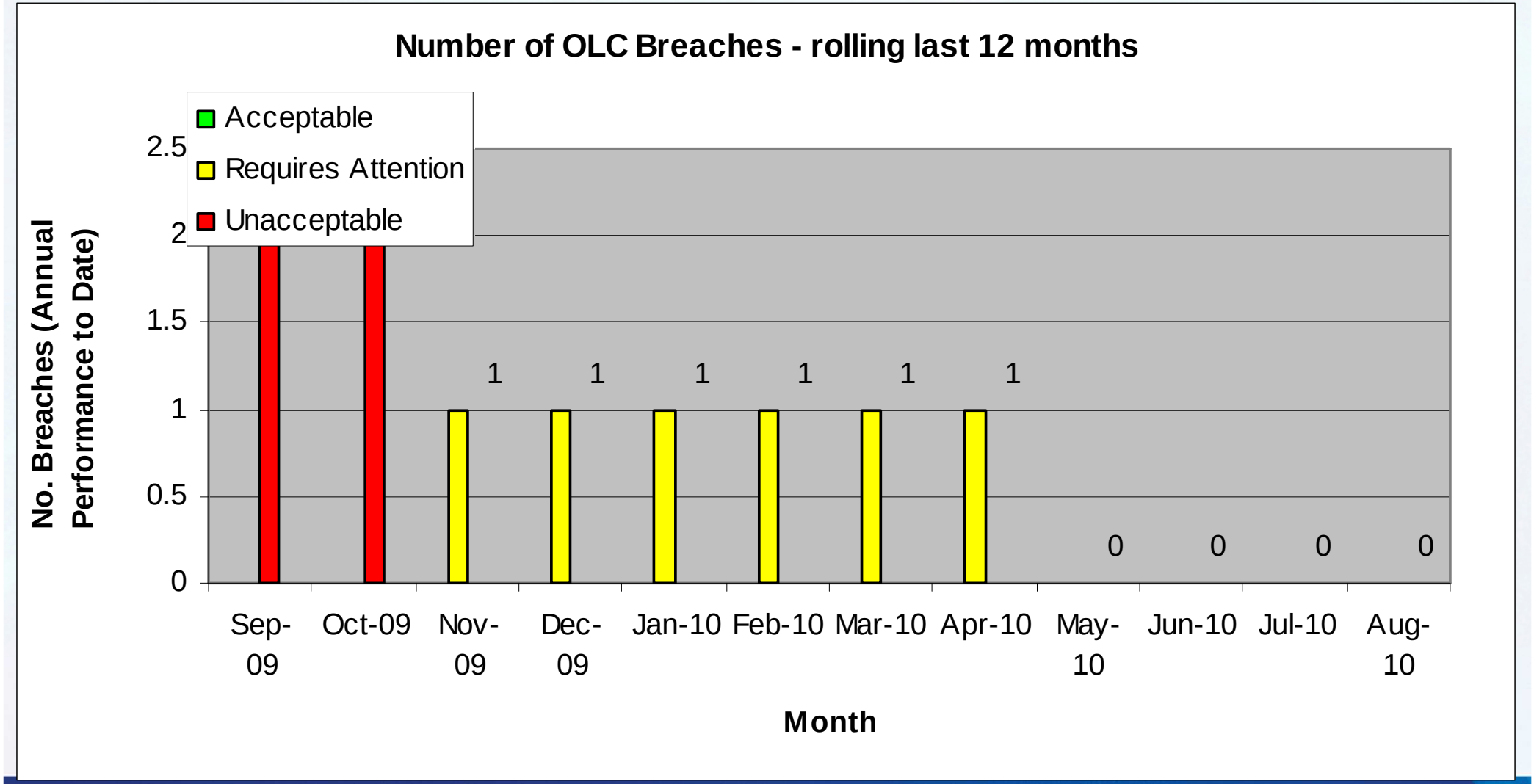
Protection System



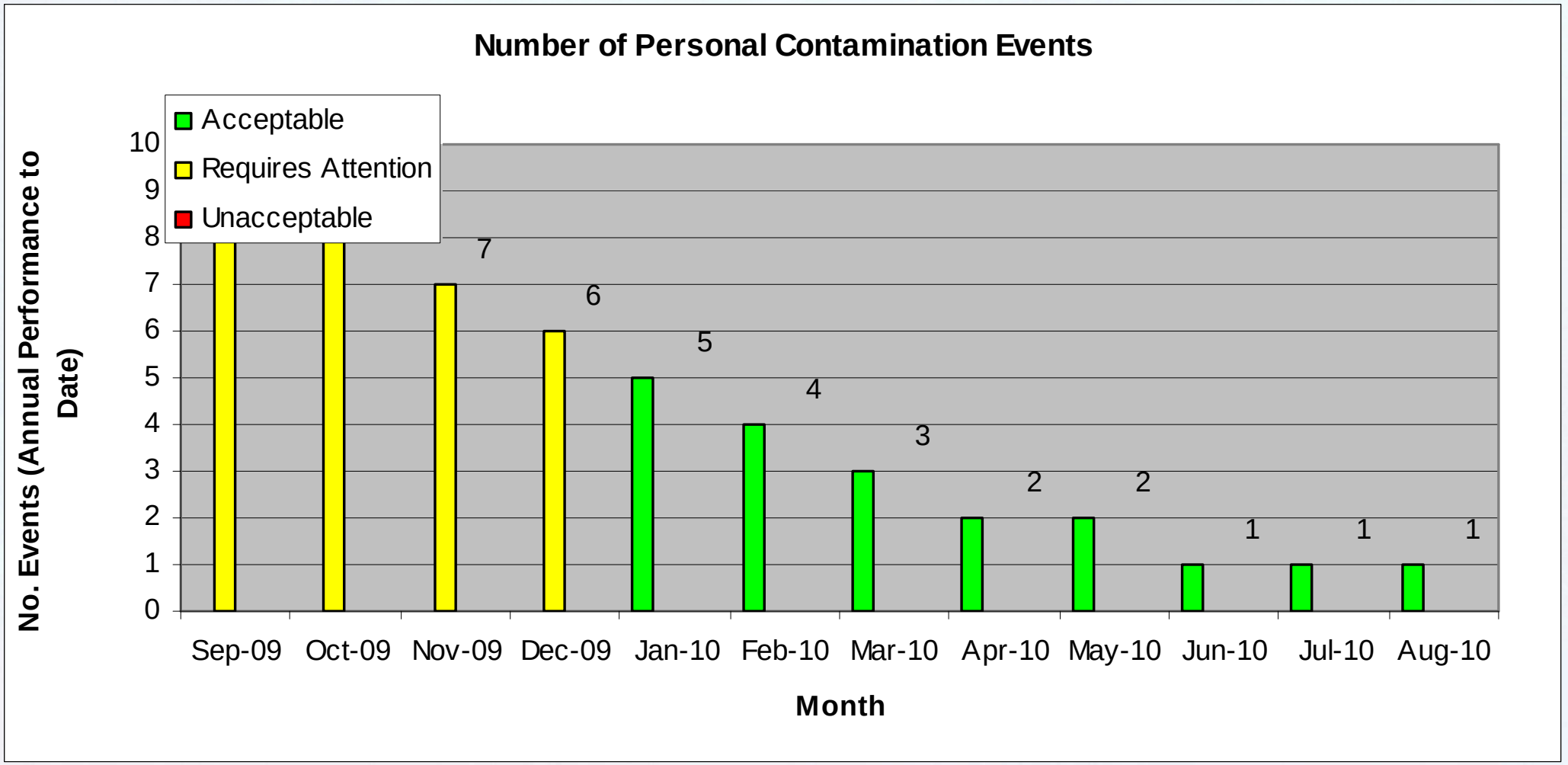
INES Level


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



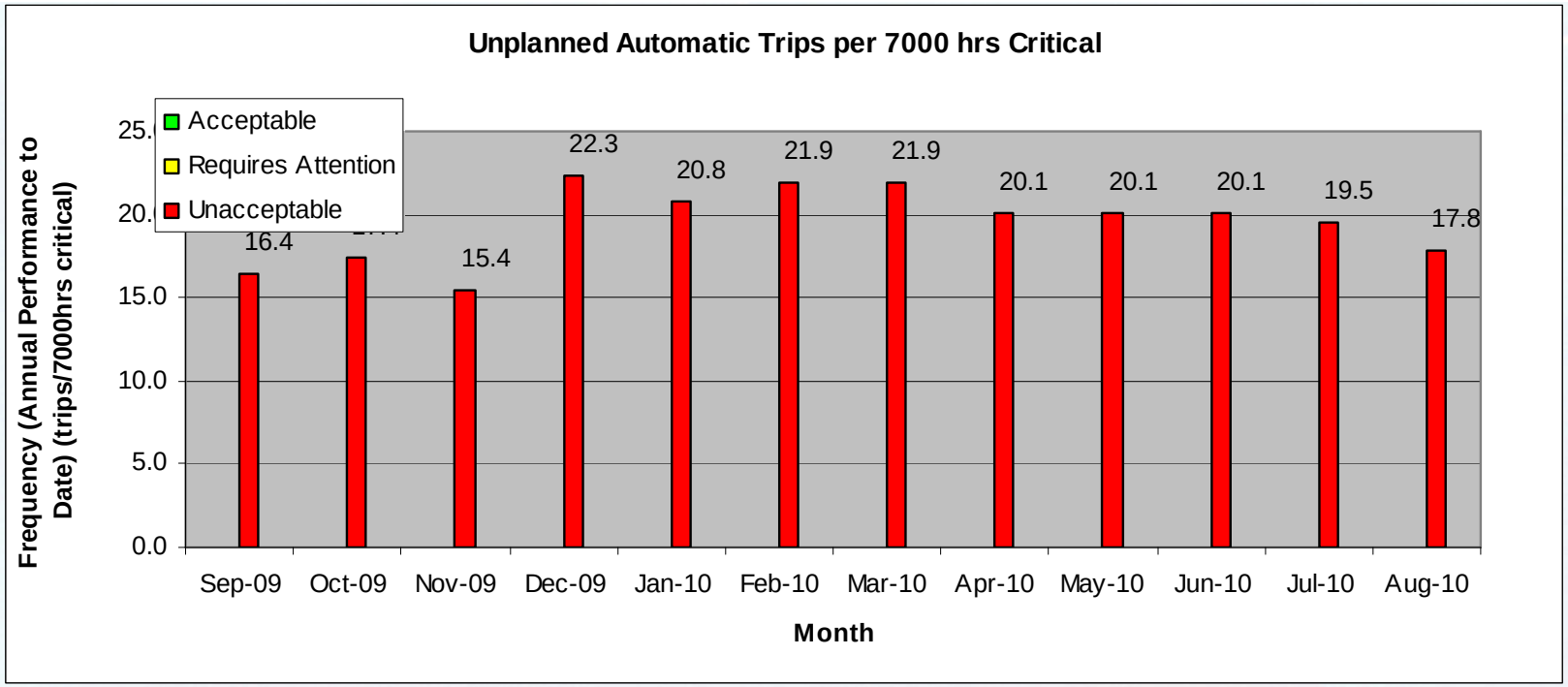
Staff contamination

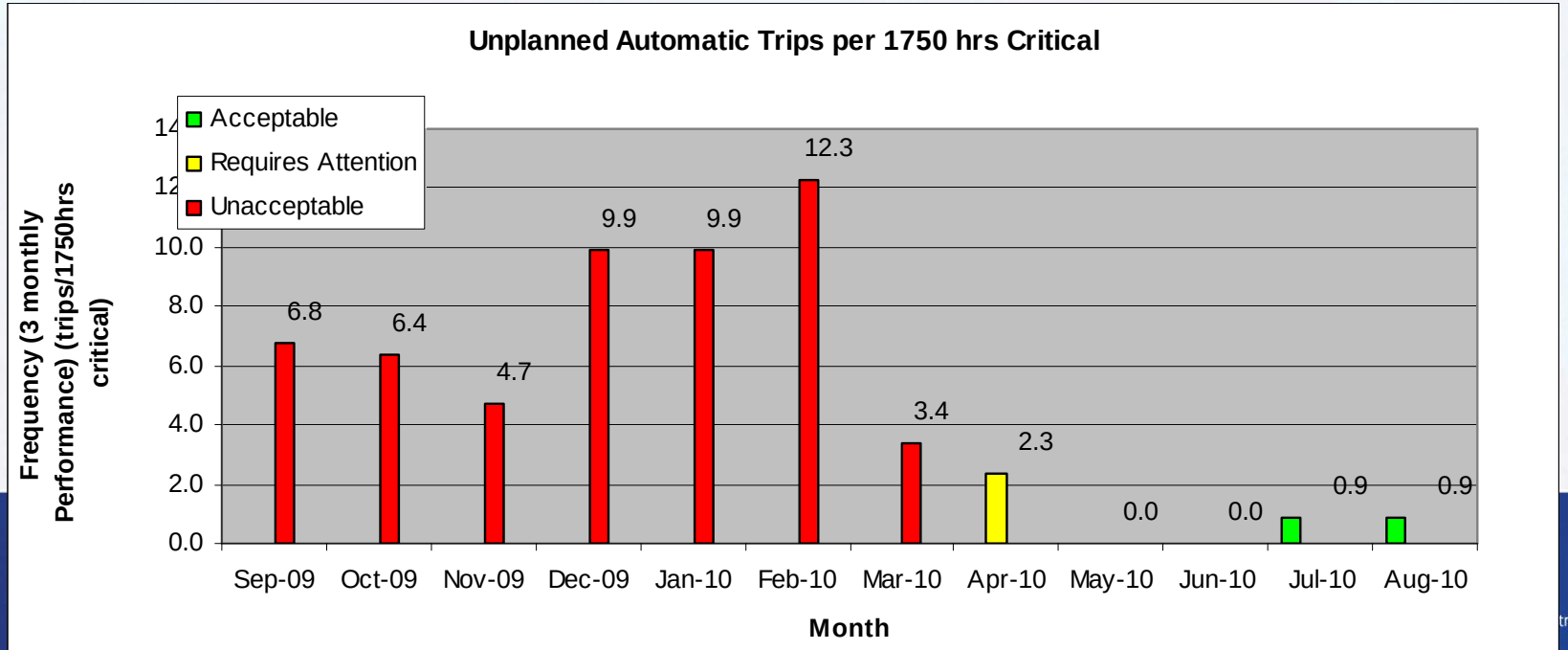


Safety Performance Indicator	Annual Goal	May 10	June 10	July 10
Unplanned automatic trips per 7000 hrs critical	6	20.1	19.5	17.8
Number of FRPS/SRPS actuations when critical not generating a reactor trip, rolling last 12 months	6	7	9	9.0
Number of reportable events INES > 0, rolling last 12 months	0	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. 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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