IP HUMAN factors no 4
safety information bulletins

For information on the series of safety information bulletins, see http://energyinst.org.uk/humanfactors/sib

OVERVIEW: *Guidance is available on the problems with alarms and what measures to take to improve alarm systems. This Safety information bulletin describes a practical approach that has been used to improve alarm systems at a petroleum refinery and to reduce the burden on operators caused by alarms.*

improving alarm systems

"An alarm system is saying to the operator 'do something about this urgently', 'look at this soon', 'don't forget this problem'." (See EEMUA *Alarm systems, a guide to design, management and procurement.*)
An alarm system that overwhelms the operator with alarms or otherwise makes it difficult to respond is thus ineffective.

A practical approach to alarm improvement This case study describes how alarm improvements were carried out using the approach, albeit slightly modified, set out in EEMUA *Alarm systems, a guide to design, management and procurement*. It provides several practical tools.

Aim
Make alarms more effective
Reduce alarm 'floods'
Enable quicker recovery from upsets
Prevent problem escalation
Monitor plant performance

Result
Total number of alarms reduced by 35%
Repeating alarms reduced by 85%
Disabled alarms reduced by 15%
Duplicate alarms reduced by 70%

Plan for alarm review and modification

Conduct an opinion survey
Find out the main problems with alarms in the company.

Develop alarm philosophy
Describe what alarms are for:
- an alarm is a warning for intervention;
- alarms are required when the control system cannot cope;
- if rapid operator response is not required then an alarm is not required.

The alarm system should allow the operator adequate time to respond.
Alarm set points are outside the normal operating zone.
The alarm system should allow for human limitations (response times, ability to see/hear alarms; workload).
Alarms should be a help not a hindrance.
Alarms should be prioritised based on severity of:
- safety, environmental and financial consequences of the condition alarmed (see Figure 1);
- time available to respond, in order of whether the alarm indicates an emergency or a 'high' or 'low' state.

Alarm information should be clearly documented (e.g. what initiates an alarm, set points, location, design, type, and what action to take).
Changes should be managed – changes to plant or operating philosophy affecting alarms or changes such as alarm design, location or set points should be subjected to change control procedures.
Plant and personnel safety should not rely on alarms only.
Alarms should reduce demands on safety systems.

Develop alarm management guide
Definition of alarm: an alarm is a warning to the operator that immediate action is required to correct a condition on the plant.
Set out the key design principles (based on good ergonomics).
Decide what should be alarmed:
- operational error;
- equipment mal-operation;
- protection of equipment;
- aim to reduce demand on safety systems;
- major equipment shutdown causing further effects on plant systems.

Decide what should not be alarmed:
- events that do not require operator response;
- status changes;
- events too fast to respond to;
- control system signals indicating successful action;
- items that are already alarmed directly or indirectly.

Alarm set points should be:
- at the point where operator action is required;
- when system parameters move outside normal operating zones (but are still safe);
- on the boundary between normal and upset states.

Coordinate alarm reviews:
- Develop alternative means of providing status and alert information only.
- Implement modifications based on those reviews (Figure 2) and allocate responsibilities to specific personnel to carry the modifications forward (Table 1).
- Develop performance indicators and conduct monitoring and further review post implementation.

Conduct audits of alarm systems and of the review system itself.
Consider the need for more sophisticated 'smart' systems for alarm handling if modifications do not resolve alarm problems.

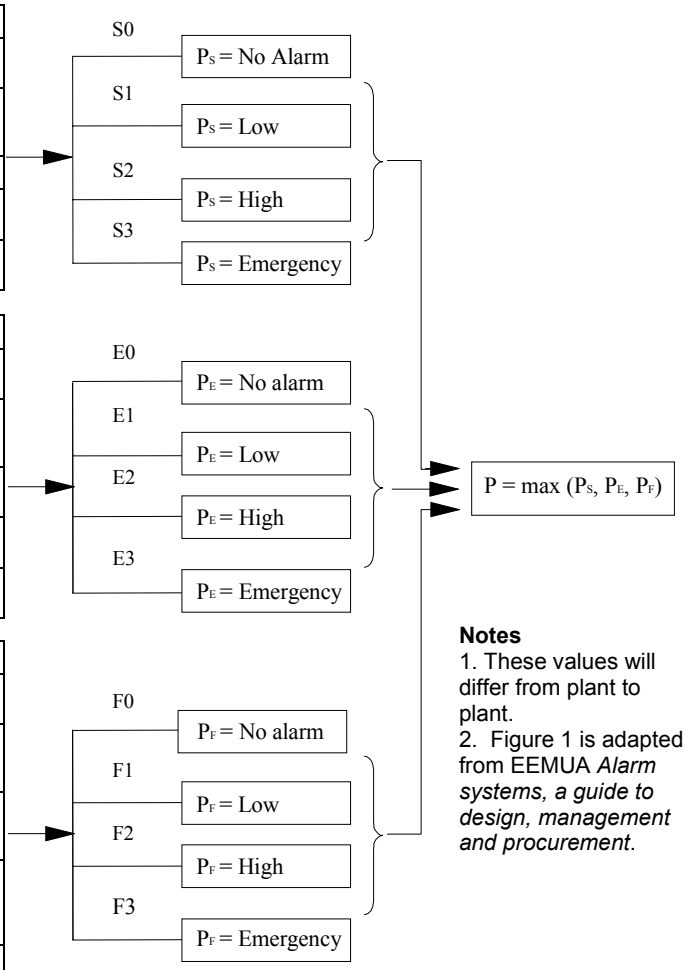
Conduct alarm reviews
Select an experienced process engineer to lead the team. Include a control engineer or technician, a process technician and a safety engineer (who may be needed only part-time to ensure consistency of reviews). See Table 1. Team objectives will be to:
- minimise the number of alarms;
- ensure that alarms:
  - have the correct set points;
  - have the correct priority;
  - have defined operator responses assigned to them;
  - appear at a manageable rate.

The following tools have proven useful in conducting design reviews.

Expected safety consequences			
Factor	**Size**	**Heuristic measure**	**Numeric measure of risk of injury (Note 1)**
S0	Minimum	Negligible risk of failure to respond to alarm resulting in a situation likely to cause injury	Below 10^{-3} (i.e. less than 1 in 1000 chance of injury)
S1	Small	Remote possibility of injury	$10^{-3} – 10^{-2}$
S2	Medium	Potentially dangerous situation with some possibility of putting people at risk of injury	$10^{-2} – 10^{-1}$
S3	Large	Dangerous situation with real potential for injury/death	Above 10^{-1} (i.e. greater than 1 in 10 chance of injury)

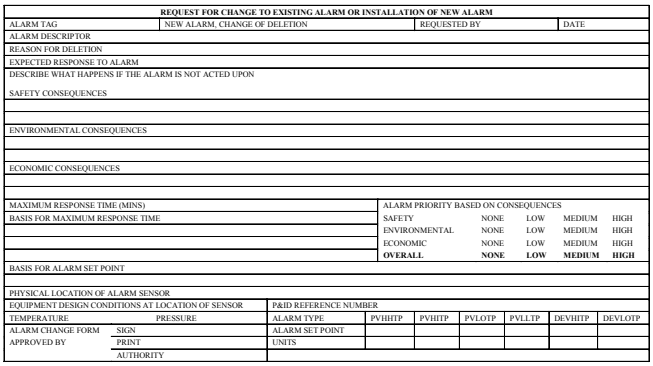
Expected environmental consequences			
Factor	**Size**	**Heuristic measure**	**Numeric measure of risk of breach of limits (Note 1)**
E0	Minimum	Negligible risk of failure to respond to alarm resulting in any breach of environmental limits	Below 10^{-3} (i.e. less than 1 in 1000 chance of incident)
E1	Small	Remote possibility of breach of environmental limits	$10^{-3} – 10^{-2}$
E2	Medium	Situation with some possibility of breach of environmental limits	$10^{-2} – 10^{-1}$
E3	Large	Situation with real potential for serious breach of environmental limits	Above 10^{-1} (i.e. greater than 1 in 10 chance of incident)

Expected financial consequences			
Factor	**Size**	**Heuristic measure**	**Numeric measure of risk of financial loss (Note 1)**
F0	Minimum	No immediate likelihood of plant damage but the possibility of this has increased. Minor loss in productivity or efficiency	Below £1000
F1	Small	Some chance of minor plant damage. Significant reduction in plant output, e.g. 10% reduction for 1 hour	£1000 - £20,000
F2	Medium	High chance of minor plant damage or low chance of serious plant damage. Significant loss of production, e.g. loss of an hour of total plant output	£20,000 - £200,000
F3	Large	High chance of serious plant damage. Serious and prolonged output loss, e.g. loss of one day of complete plant output	£200,000 +



Notes
1. These values will differ from plant to plant.
2. Figure 1 is adapted from EEMUA *Alarm systems, a guide to design, management and procurement*.

Figure 1 - Prioritising alarms based on safety, environmental and financial impact



REQUEST FOR CHANGE TO EXISTING ALARM OR INSTALLATION OF NEW ALARM

ALARM TAG | NEW ALARM, CHANGE OF DELETION | REQUESTED BY | DATE

ALARM DESCRIPTOR

REASON FOR DELETION

EXPECTED RESPONSE TO ALARM

DESCRIBE WHAT HAPPENS IF THE ALARM IS NOT ACTED UPON

SAFETY CONSEQUENCES

ENVIRONMENTAL CONSEQUENCES

ECONOMIC CONSEQUENCES

MAXIMUM RESPONSE TIME (MINS)

BASIS FOR MAXIMUM RESPONSE TIME

ALARM PRIORITY BASED ON CONSEQUENCES

SAFETY	NONE	LOW	MEDIUM	HIGH
ENVIRONMENTAL	NONE	LOW	MEDIUM	HIGH
ECONOMIC	NONE	LOW	MEDIUM	HIGH
OVERALL	**NONE**	**LOW**	**MEDIUM**	**HIGH**

BASIS FOR ALARM SET POINT

PHYSICAL LOCATION OF ALARM SENSOR

EQUIPMENT DESIGN CONDITIONS AT LOCATION OF SENSOR | P&ID REFERENCE NUMBER

TEMPERATURE | PRESSURE | ALARM TYPE | PVHHTP | PVHITP | PVLOTP | PVLLTP | DEVHITP | DEVLOTP

ALARM CHANGE FORM APPROVED BY: SIGN / PRINT / AUTHORITY | ALARM SET POINT | UNITS

Figure 2 - Alarm modification request form
For downloadable version, see
http://www.energyinst.org.uk/humanfactors/sib4Figure 2

	Production manager	Production superintendent	Process technician	Advanced control leader	Production control leader	Advanced control engineer	Area leader	Lead process engineer	Experienced process engineer	Process engineering leader	Safety engineer	Control engineer	Trained auditor
Alarm management owner	A	R											
Design of alarm guidelines	A	C		C	C			C		C	R	C	
Alarm approval		A/R					C	C			C		
Unit alarm review			R			R			A				
Performance monitoring and review	A	R	C								R		
Alarm document management	A				R								
Audit	A												R

Key: A = Accountable R = Responsible C = Consult I = Inform

Table 1 Allocation of responsibilities in alarm reviews

References and further information

IP *Human factors briefing notes resource pack,* No. 3 *Alarm Handling*, Energy Institute, ISBN 0 85293 400 9. See Energy Institute website: http://www.energyinst.org.uk/humanfactors/bn.
HSE *Better alarm handling*, Chemicals Sheet 6 (CHIS 6), HSE (2000). See HSE website: http://www.hse.gov.uk/pubns/index.htm.
EEMUA *Alarm systems, a guide to design, management and procurement*, publication No. 191 (1999), ISBN 0 8593 1076 0.