

# Managing the Lifecycle of Independent Protection Layers

Patrick Fisher, Provenance Consulting, October 6, 2016



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# Buncefield Fire

“...had more to do with slackness, inefficiency and a more-or-less complacent approach to matters of safety...”



“...compliance with many safety policies and procedures was deficient at all levels of the refinery...”

## Texas City Explosion

# Overview

What is an IPL?

*When is a safeguard an IPL?*

*What makes a good IPL?*

What criteria of IPLs need to be managed?

*CCPS seven core attributes of IPLs*

*What needs to be documented to meet these criteria?*

What does the management of IPLs look like in practice?

*How does the documentation get managed?*

*How can software help manage the documentation?*

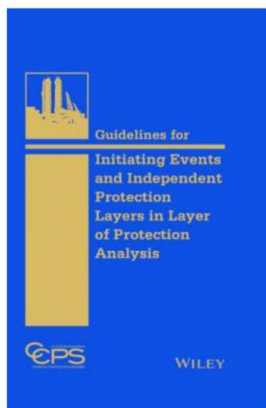
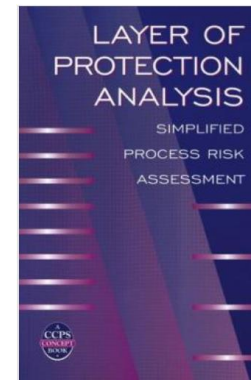


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# What is an IPL?

“A device, system, or action that is, capable of preventing a scenario from proceeding to its undesired consequence, **independent of the initiating event or the action of any other layer of protection associated with the scenario.** The effectiveness and independence of an IPL must be auditable”

*Layer of Protection Analysis: Simplified Process Risk Assessment, CCPS 2001*

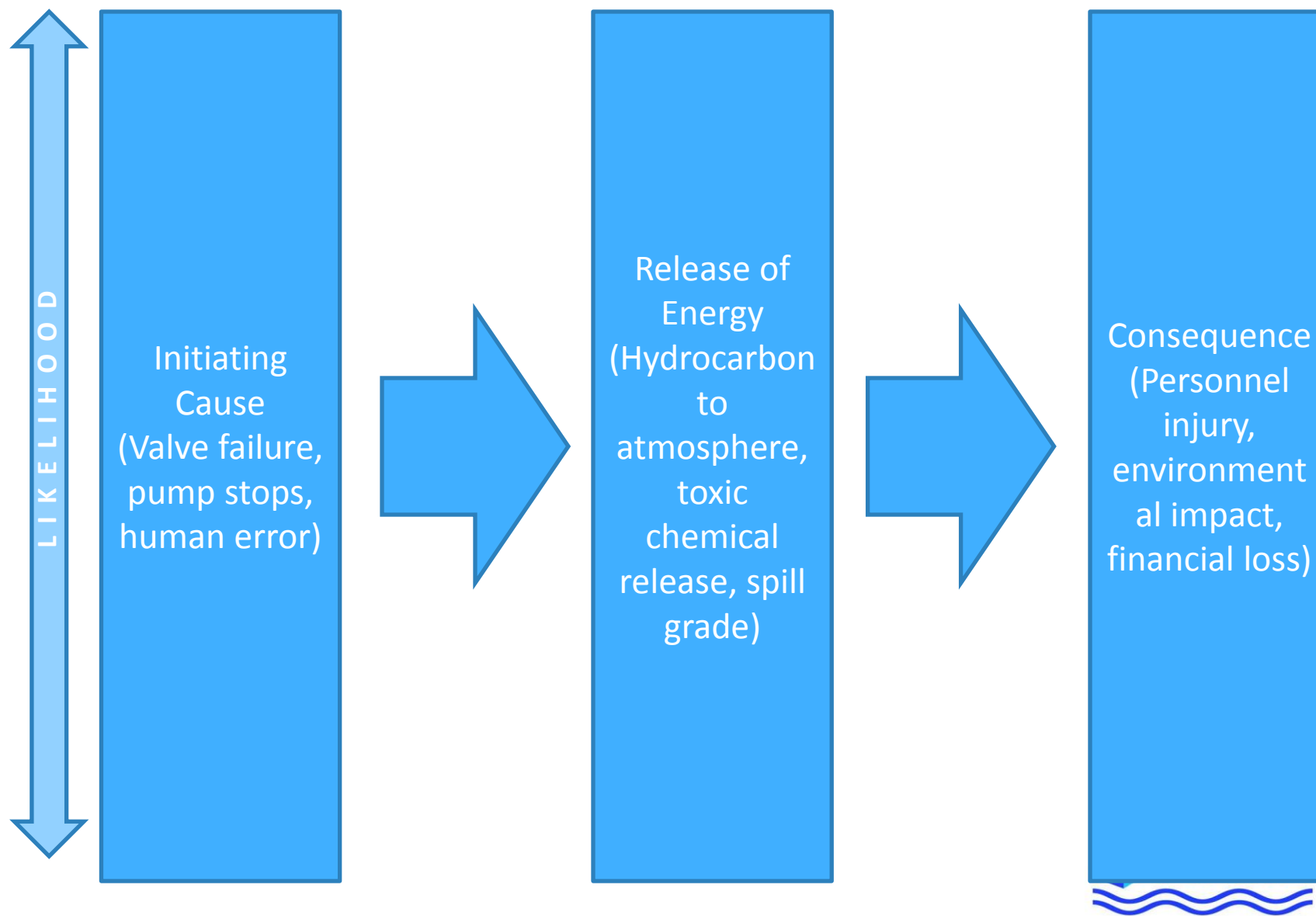


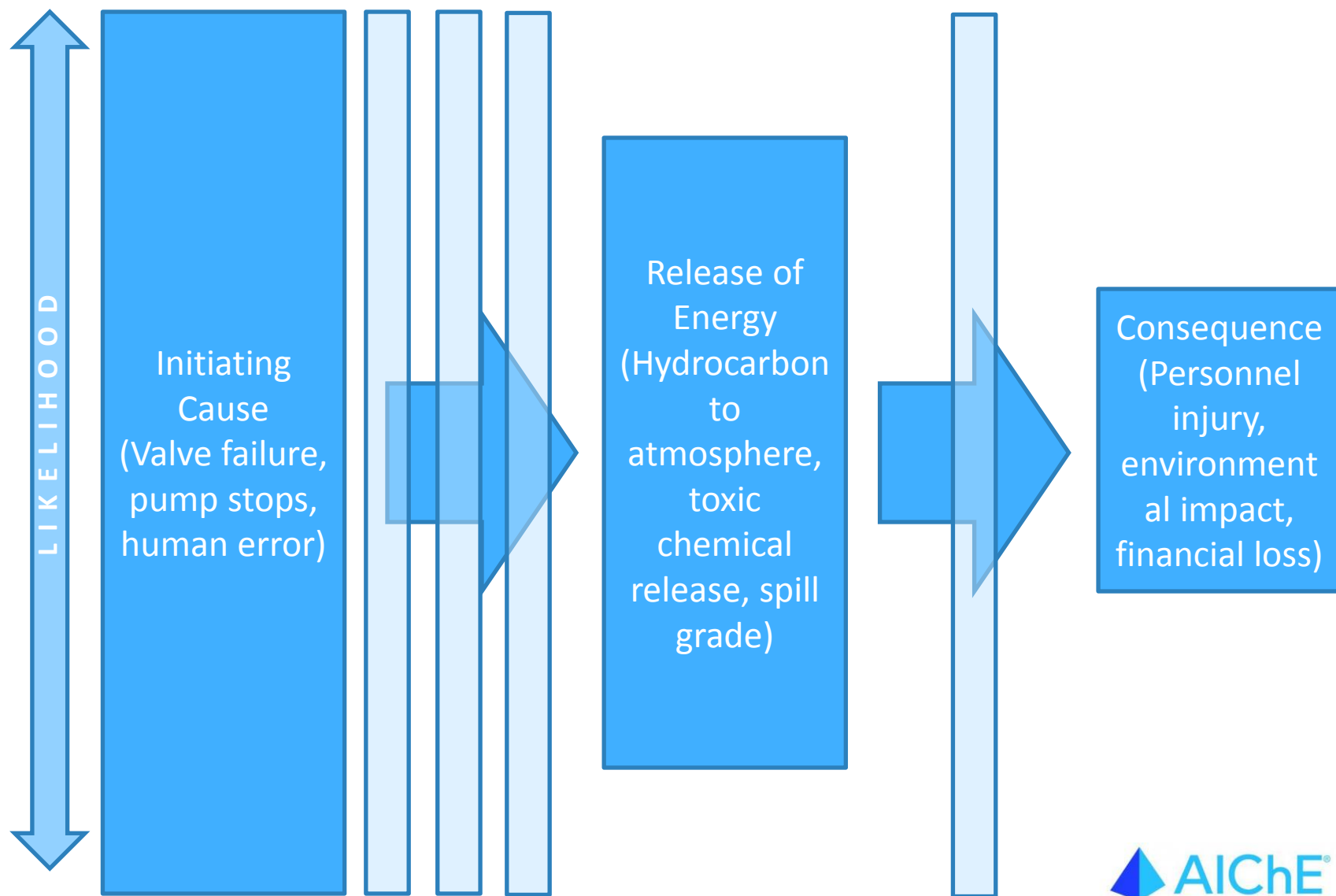
“A device, system, or action that is capable of preventing a scenario from proceeding to the undesired consequence **without being adversely affected by the initiating event or the action of any other protection layer associated with the scenario**”

*Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis, CCPS 2015*



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# Safeguards vs IPLs

*Any safeguard identified in the HAZOP can potentially qualify as an IPL.*

Independent

Effective

Auditable

Independent Protection Layers



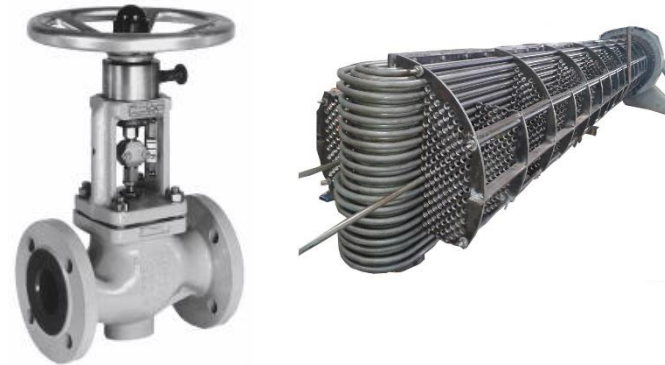
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# Independence

Plugging



Mechanical integrity



*“IPLs should be sufficiently independent such that the degree of interdependence is not statistically significant”*

*Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis,  
CCPS 2015*



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# Independence

*A safeguard from the HAZOP can be considered independent if*

It has non-significant interdependence with initiating event

It has non-significant interdependence with other IPLs

It is not adversely affected by the initiating event

It is not adversely affected by other IPLs

Independence



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# Effective

*“A device, system, or action that is **capable of preventing a scenario from proceeding to the undesired consequence** without being adversely affected by the initiating event or the action of any other protection layer associated with the scenario.”*

*Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis, CCPS 2015*



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# Effective

## Effective Relief Valve



- Sized for scenario
- Set at the right pressure
- In the right service (plugging, clean)
- Regularly tested or replaced

## Effective Alarm



- Would detect the scenario
- Set with sufficient time to act
- Reliable instrument
- Operator action is clear



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# Effective

*A HAZOP safeguard can be considered effective if*

It is functional enough to prevent the scenario without any outside interference

It has sufficient integrity to provide the required risk reduction

It is reliable enough to provide sufficient risk reduction between tests

Effectiveness



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# Auditable

*“The effectiveness and independence of an IPL must be auditable.”*

*Layer of Protection Analysis: Simplified Process Risk Assessment, CCPS 2001*

## Auditable Relief Valve



Can be tested on a regular basis

Can be checked for service (clean, plugging)

## Auditable Alarm



Can be tested on a regular basis

The intended operator response is documented

Actual operator responses are documented



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# Safeguards to IPLs

	Independent	Effective	Auditable
Procedures	Moderate	Easy	Moderate
Alarms	Easy	Easy	Easy
Trips	Easy	Easy	Easy
Relief Valves	Easy	Easy	Easy
Operator rounds	Easy	Hard	Moderate
Signage	Hard	Hard	Easy
Samples	Easy	Hard	Moderate
Emergency response plans	Moderate	Moderate	Moderate
Post-release (deluge, etc)	Easy	Easy	Moderate



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# Safeguards to IPLs

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Samples	Easy	Hard	Moderate
Emergency response plans	Moderate	Moderate	Moderate
Post-release (deluge, etc)	Easy	Easy	Moderate



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# What is an IPL?

An IPL is a safeguard which we choose to focus our attention on because it is easier to quantify, qualify, and verify the amount of safety protection provided

	Independent	Effective	Auditable
Procedures	Moderate	Easy	Moderate
Alarms	Easy	Easy	Easy
Trips	Easy	Easy	Easy
Relief Valves	Easy	Easy	Easy
Emergency response plans	Moderate	Moderate	Moderate
Post-release (deluge, etc)	Easy	Easy	Moderate

hE®

# What comes after identifying IPLs?



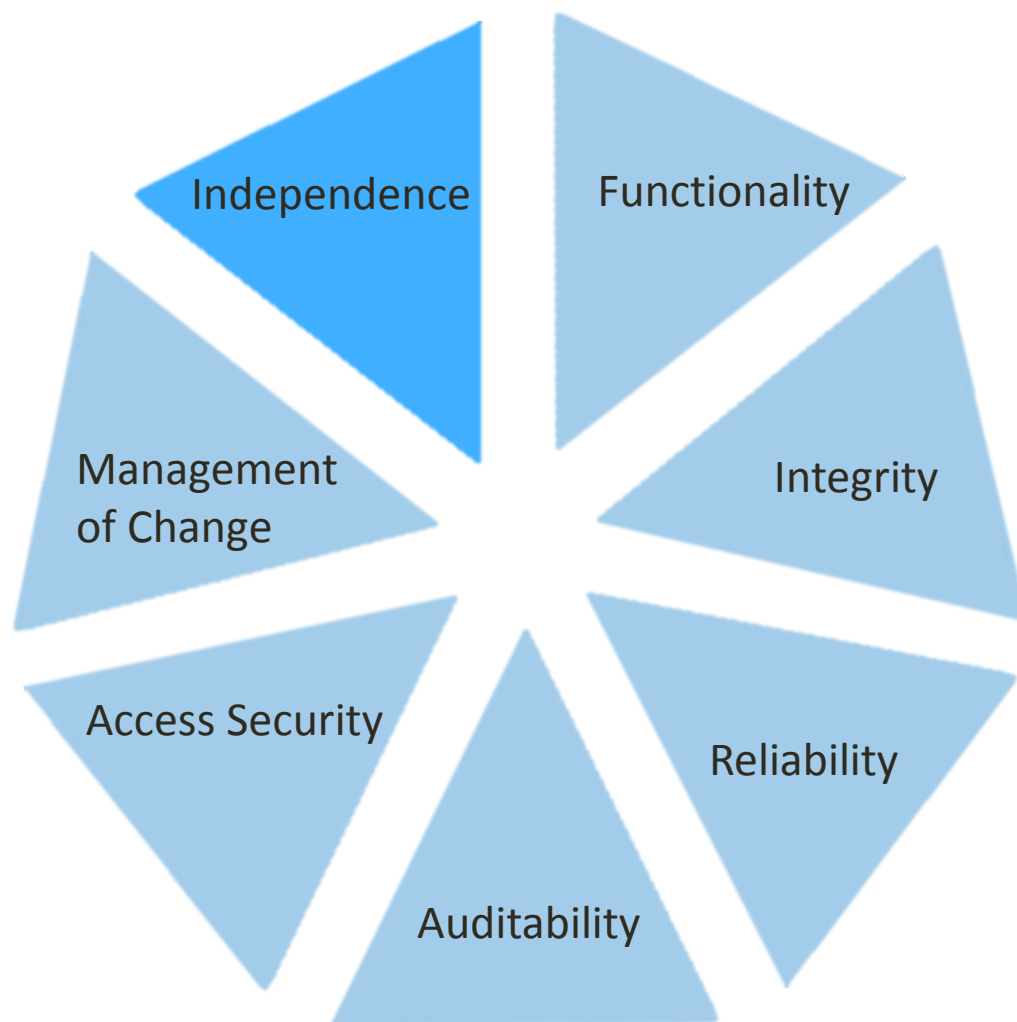
There are seven core attributes to an IPL which need to be managed through the IPL lifecycle

*Guidelines for Safe and Reliable Instrumented Protective Systems (CCPS 2007), Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis, CCPS 2015*



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# Independence



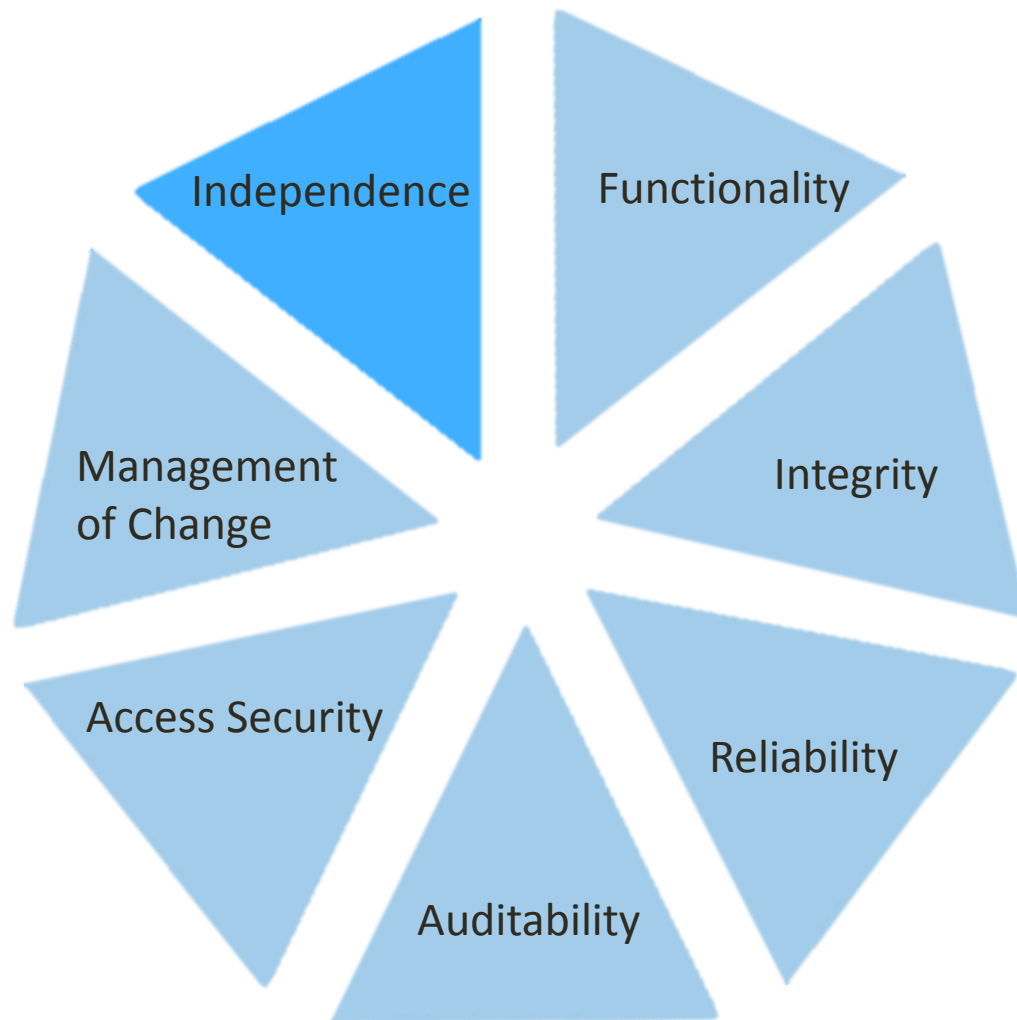
For each IPL, document all associated equipment, personnel, and control systems.

For each initiating event, document the potential failures, including individual pieces of equipment and personnel



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# Independence

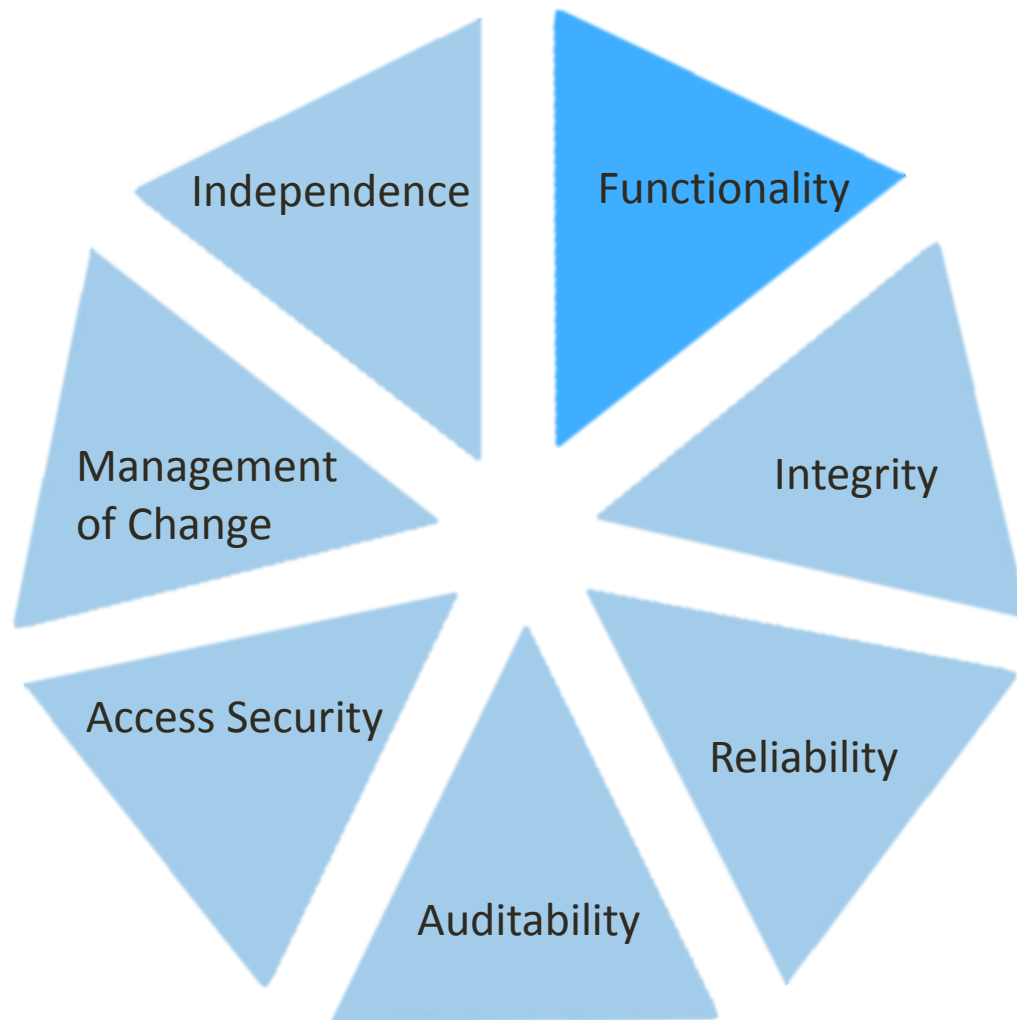


If any of the elements are common, then ensure that the likelihood/probability of failure of the common element is less than the total PFD of the combined IPLs/IEFs



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# Functionality



Document all relevant requirements for the IPL, including:

Instrument  
Set Point

Logic Solver System

Final element (e.g. valve or operator)

Time required to respond

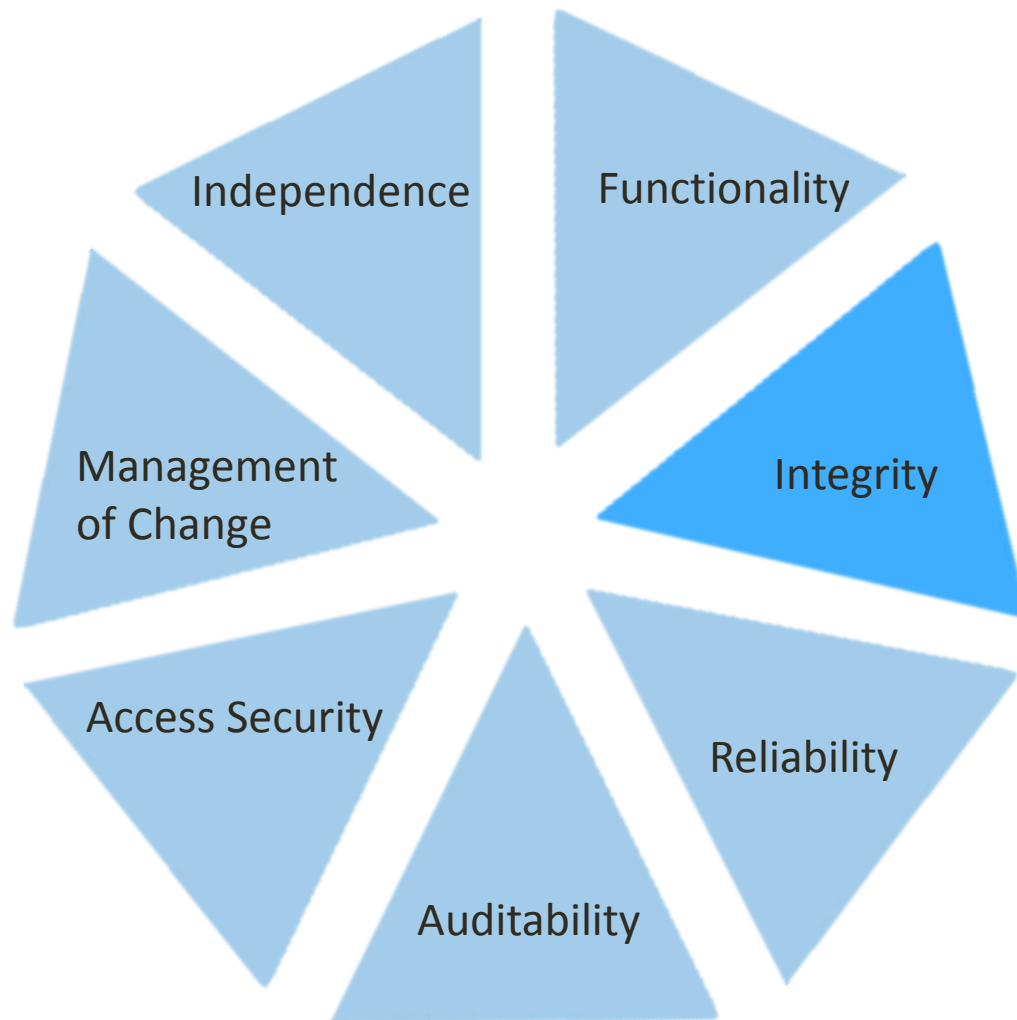
Expected result of IPL activation



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# Integrity



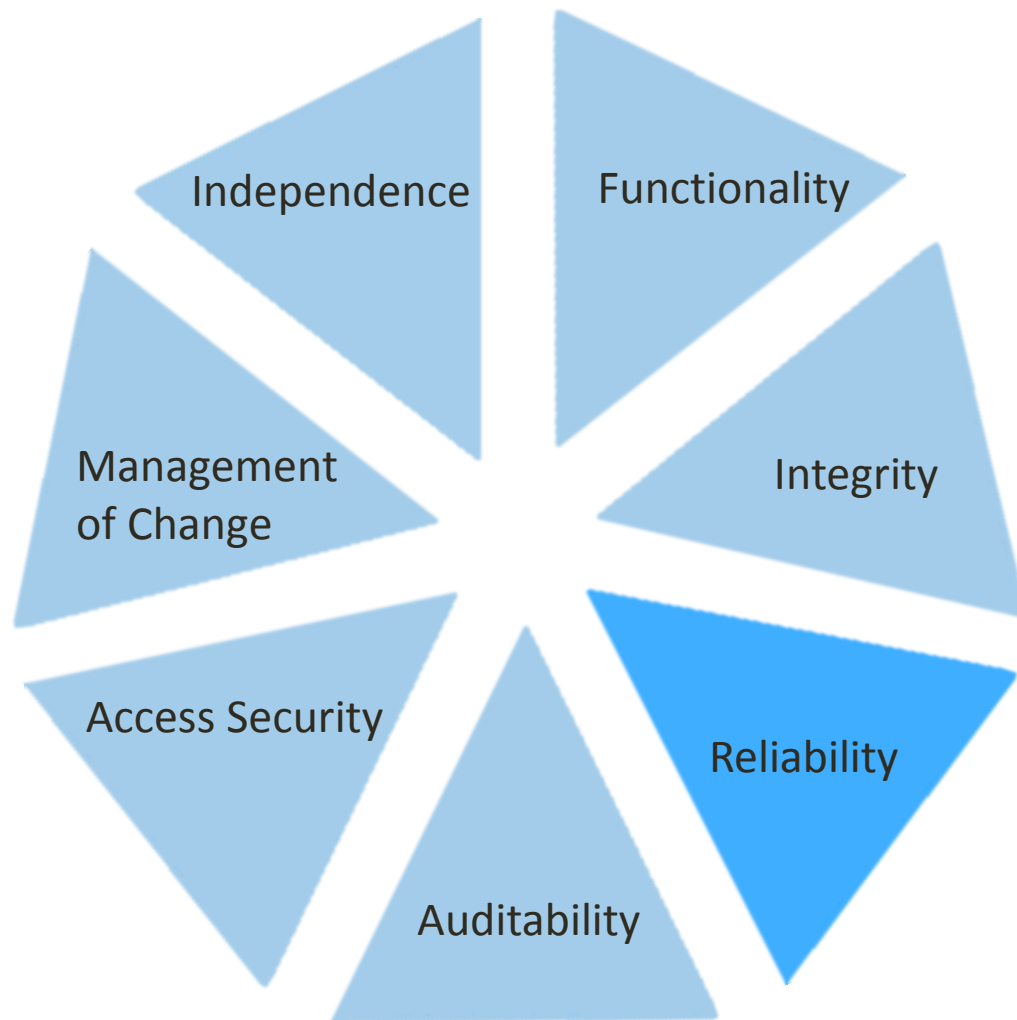
For each cause-consequence pair, document the PFD of the IPL. This is the maximum (or worst) PFD that can be accepted from the IPL.

Integrity is limited to the weakest element



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# Reliability



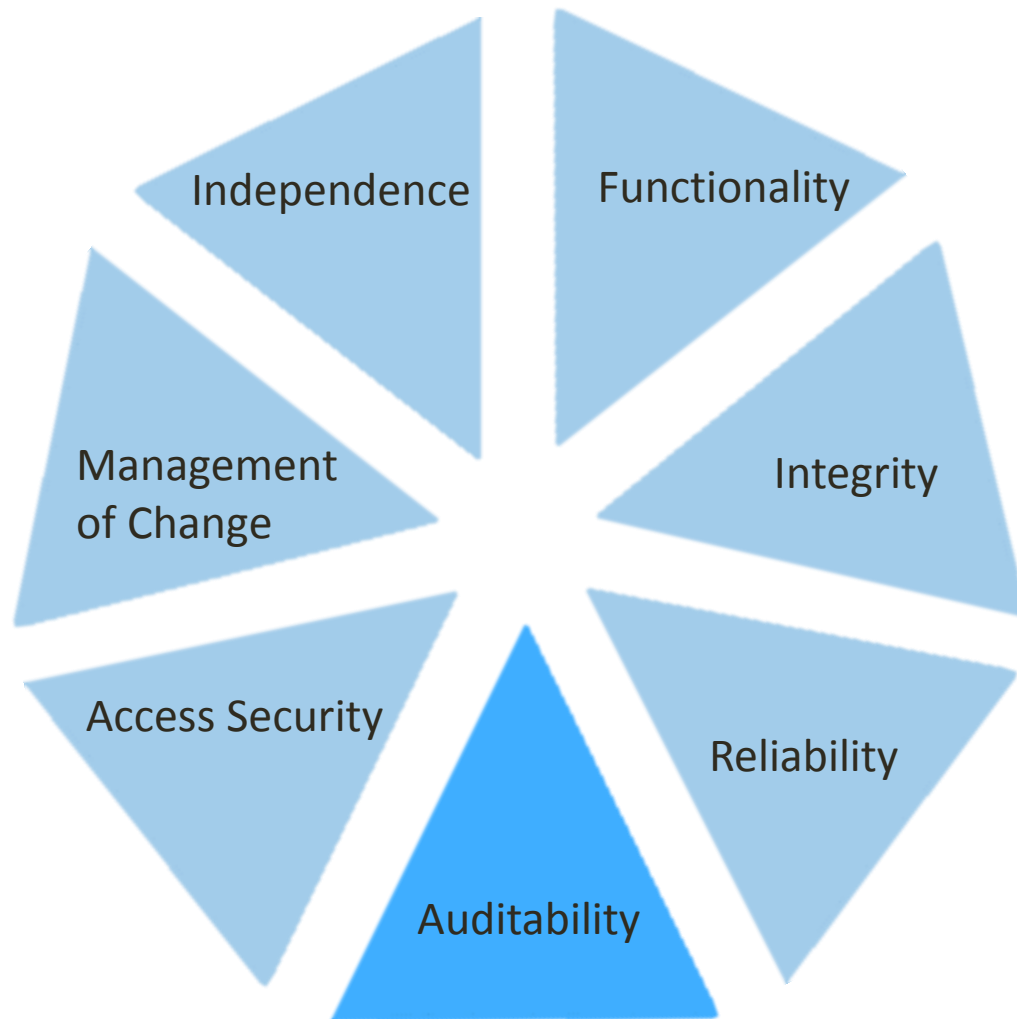
Document the design conditions expected, and include a plan for mitigation if the IPL is not available

The mitigation plan ensures reliability of the system even when the primary IPL is not available



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# Auditability



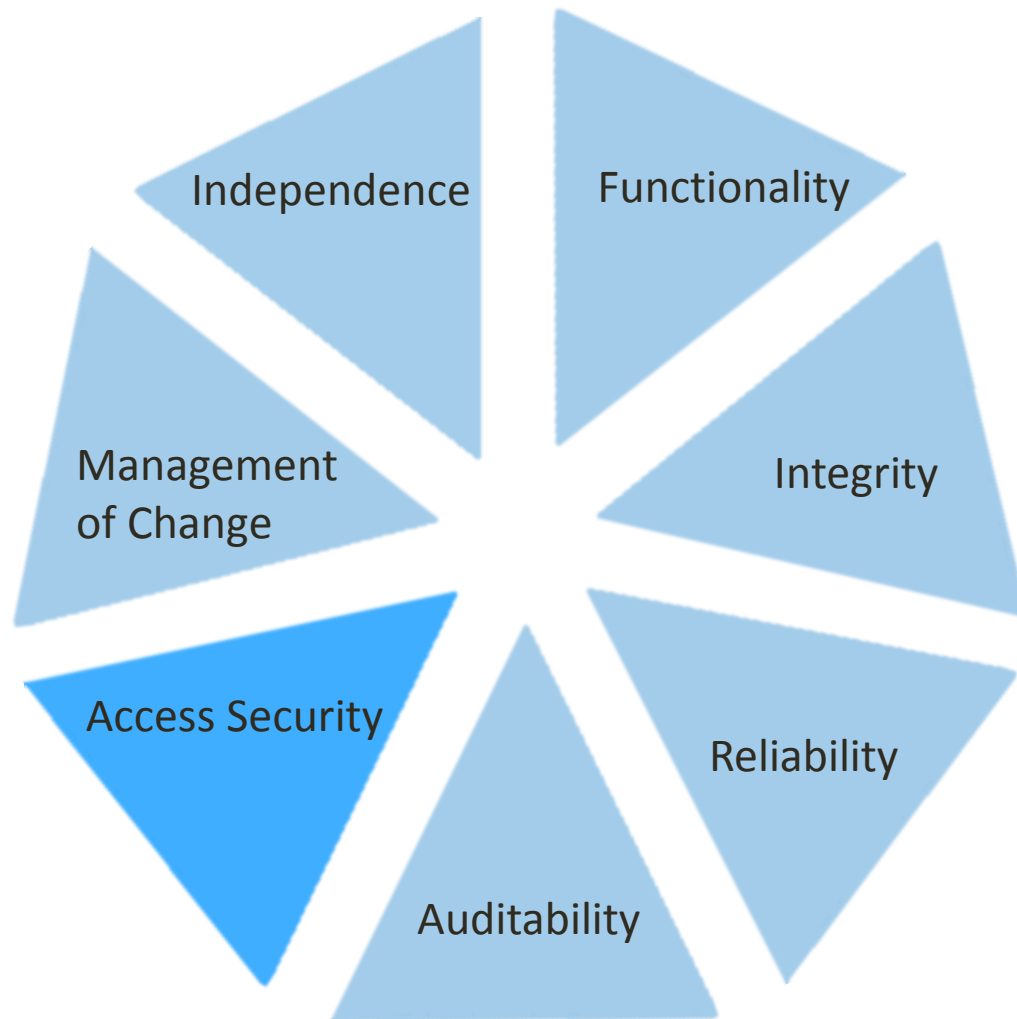
Prepare an audit plan which includes how to verify the independence and effectiveness of the IPL.

At a minimum, the independence and effectiveness should be reviewed along with the PHA cycle (5 years)



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# Access Security



IPLs must have physical and/or administrative controls to reduce unauthorized system changes

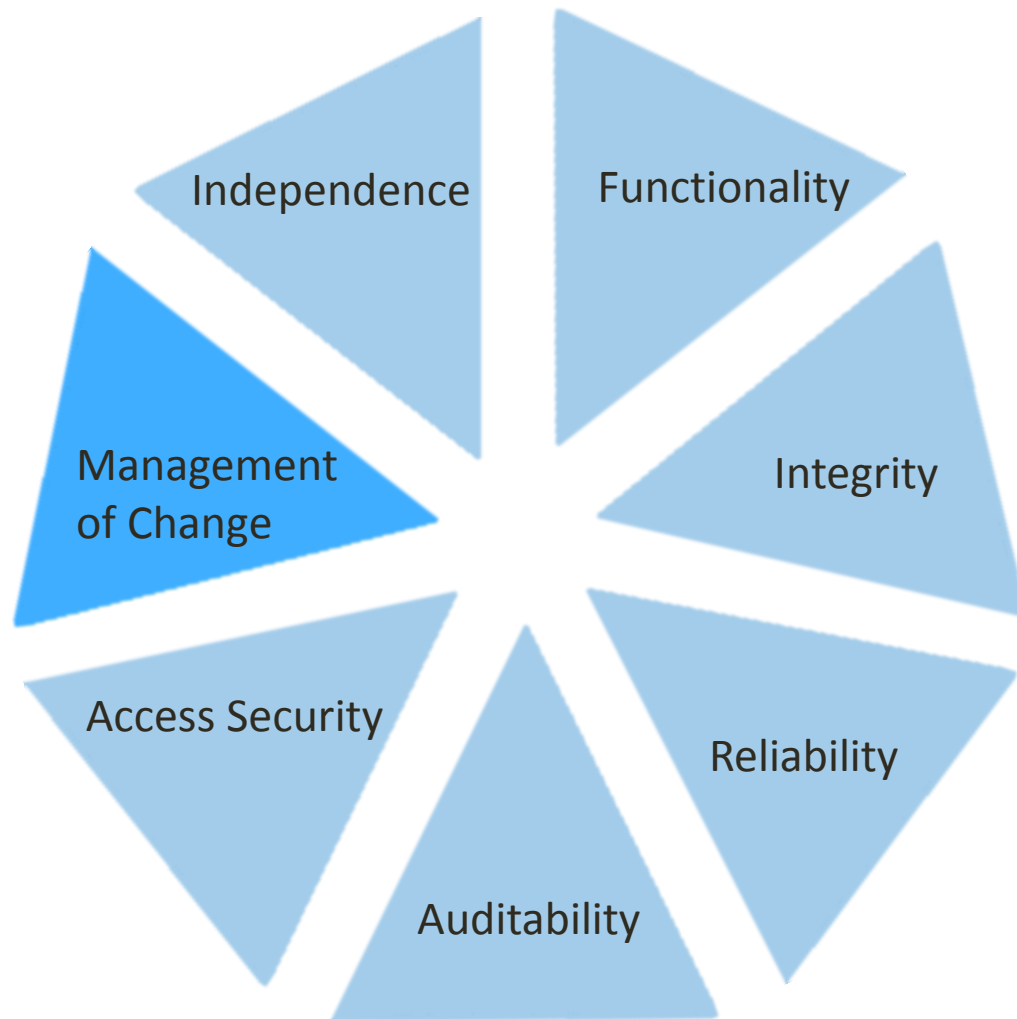
This includes malicious and accidental change

Document the controls in place so that they can be audited



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# Management of change



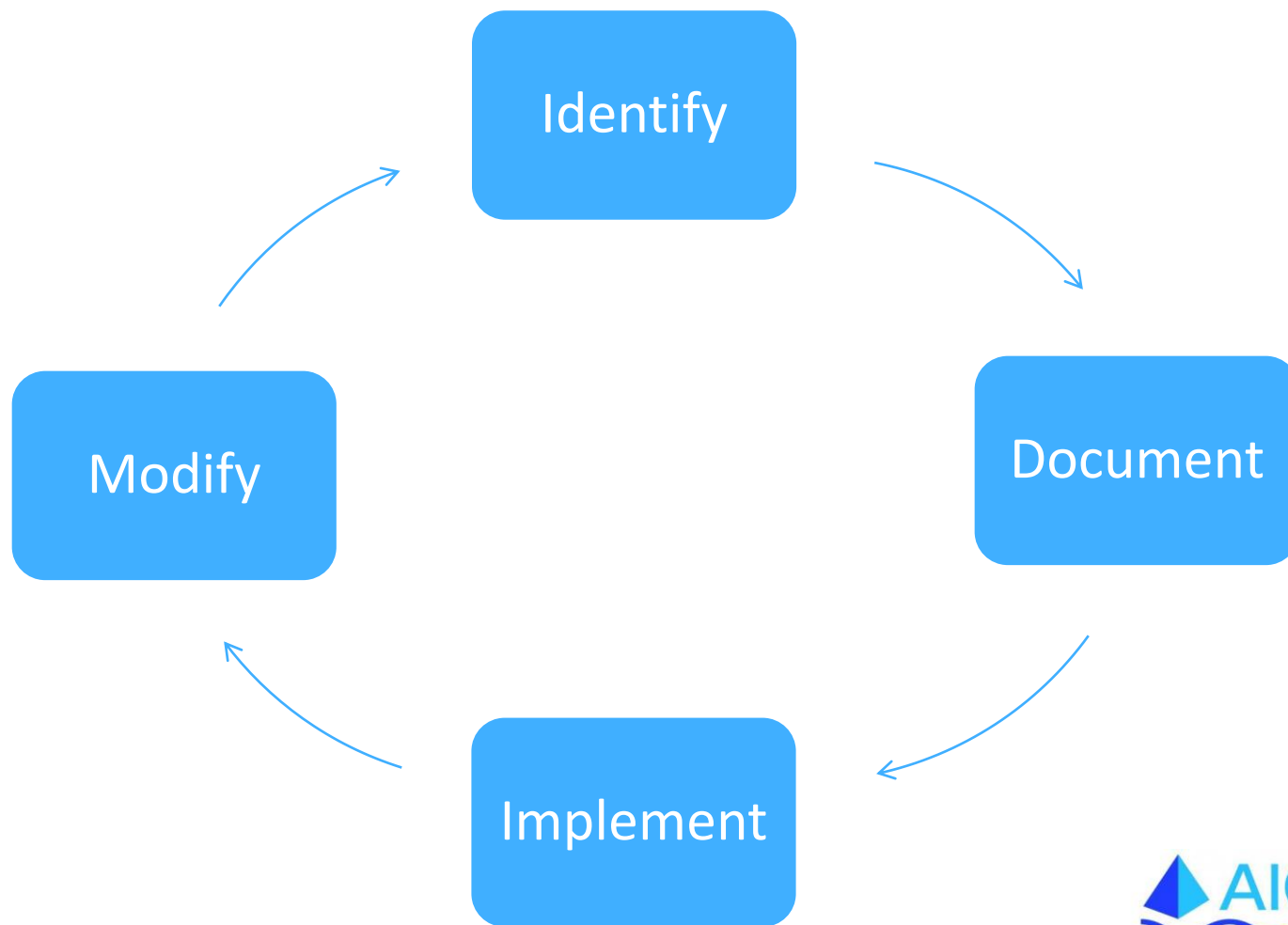
Flag any change that may affect independence or effectiveness

If any element of an IPL changes, all other associated IPLs and Initiating events should also be reviewed for impacts.



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# What comes after identifying IPLs?



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# Identifying and Documenting IPLs

## IPL Description

PI-101 high pressure alarm, set at 100psig, will alarm through the control system and the Area B board operator will respond within 8 minutes by closing the fuel gas valve HV-102 before the pressure reaches the V-104 MAWP of 120psig.

## Source

[2016 Area B HAZOP/LOPA Revalidation, Nodes 2 and 3.](#)

## Components

Instrumentation	Control System	Final Elements	Personnel
PT 101	I/O Card 856 CPU 927 I/O Card 639 Logic block 827 Screen 21	HV-102 HV-102 Solenoid	Area B Board Operator Area A/B Instrumentation tech



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# Identifying and Documenting IPLs

## Identified Hazards

PHA Ref.	Consequence	Cat.	Severity	Risk	PFD
2.6.1.3	Potential overpressure of V-104 by greater than 2x MAWP (120psig). Potential for multiple gasket failures and loss of containment of hydrocarbon with potential fire and personnel injury.	Safety	Permanent Disability	2 – Moderate	0.1
3.4.3.1	Potential overpressure of V-104 by greater than 2x MAWP (120psig). Potential for multiple gasket failures and loss of containment of hydrocarbon with potential fire and personnel injury.	Safety	Permanent Disability	1 - Low	0.1

## Process Safety Time

PHA Ref.	Time from detection to release	Expected time to action	Expected Result
2.6.1.3	15 minutes	8 minutes	Tower temperature TI-101 will drop and PI-101 will no longer read high.
3.4.3.1	18 minutes	8 minutes	Tower temperature TI-101 will drop and PI-101 will no longer read high.



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# Identifying and Documenting IPLs

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# Identifying and Documenting IPLs

## Initiating Event: FV-306 malfunctions closed or manual block valves closed

Instrumentation	Control System	Mechanical Elements	Personnel
FT-306 PT-100	I/O Card 855 CPU 927 I/O Card 656 Logic block 821 Screen 21	FV-306 FV-306 Solenoid	Area B Board Operator Area A/B Instrumentation tech Area B field operator

Common elements notes: CPU is common between IPL and IE, however the frequency of CPU failure is acceptable for this condition (0.01). Area B board operator is common between IPL, however the frequency of human failure (low stress, non-fatigued) is acceptable for this condition (0.01).

## Initiating Event: Manual block valve on unit edge misaligned closed.

Instrumentation	Control System	Mechanical Elements	Personnel
N/A	N/A	Manual Valve on Line 837 for vapor overhead between Area A and B	Area B field operator Area A field operator

Common elements notes: No common elements between IPL and IE.

## Related IPLs: Relief valve RV-902 set at 120psig, sized for blocked outlet of V-104 relieves to Area B Flare

Instrumentation	Control System	Final Elements	Personnel
N/A	N/A	RV-902 CSO Valve 5426 CSO Valve 3028 Area B Flare	Area B Maintenance tech

Common Element note: Potential for process plugging for both PI and Relief Valve. Both are in clean service, and probability is considered very low (<0.001)



# Managing a company full of IPLs

The screenshot displays the ARTS (Asset & Records Traceability System) web application. The header includes the ARTS logo, navigation links (Home, Search Equipment, Browse Equipment, Documents, Reports, Administration, Help), and a search bar. The breadcrumb trail shows the user is in the 'Reports' section. The main content area displays a report titled 'IPL Health by Facility' with a table showing health metrics for four facilities: Houston, LA, Minneapolis, and Denver. The table has three columns: Facility, IPL Health, and PSI Health. The data is as follows:

Facility	IPL Health	PSI Health
<a href="#">Houston</a>	84% - Poor	97% - Excellent
<a href="#">LA</a>	97% - Excellent	93% - Good
<a href="#">Minneapolis</a>	92% - Moderate	88% - Poor
<a href="#">Denver</a>	94% - Good	98% - Excellent

# Managing a company full of IPLs

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Unit	Independence	Effectiveness	Auditing	Access Security
<a href="#">Area A</a>	100% - Excellent	100% - Excellent	95% - Good	100% - Excellent
<a href="#">Area B</a>	65% - Very Poor	75% - Poor	80% - Poor	100% - Excellent
<a href="#">Area C</a>	95% - Good	98% - Excellent	97% - Good	100% - Excellent
<a href="#">Area D</a>	100% - Excellent	100% - Excellent	99% - Good	100% - Excellent

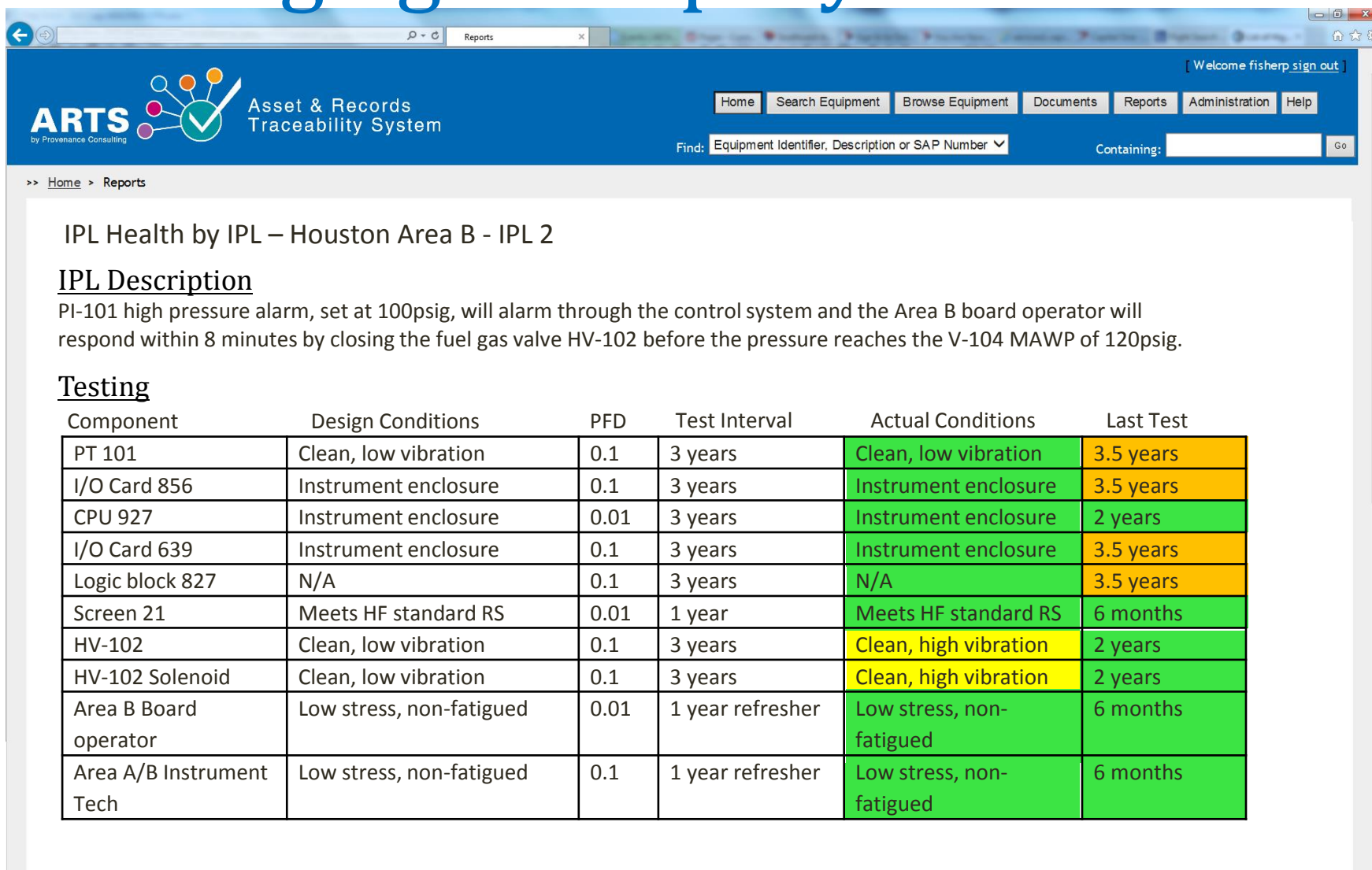


# Managing a company full of IPLs

The screenshot shows the ARTS (Asset & Records Traceability System) interface. The header includes the ARTS logo and navigation links: Home, Search Equipment, Browse Equipment, Documents, Reports, Administration, and Help. A search bar is present with the text 'Find: Equipment Identifier, Description or SAP Number' and a 'Go' button. The main content area displays a report titled 'IPL Health by IPL – Houston Area B'.

Protection Layer	Independence	Effectiveness	Auditing	MOC Detection	Access Security
<a href="#">IPL 1 – LAH-203...</a>	Verified	Verified	Up to Date	Flagged	In place
<a href="#">IPL 2 – PAH-101...</a>	Unverified	Not meeting specifications	Testing Overdue	Flagged	In place
<a href="#">IPL 3 – FAL-104...</a>	Partially Verified	Unverified	Up to Date	Not Flagged	In place
<a href="#">IPL 4 – PAL-308...</a>	Verified	Partially Verified	Testing missing	Flagged	In place

# Managing a company full of IPLs



The screenshot shows the ARTS (Asset & Records Traceability System) web application. The header includes the ARTS logo and navigation links: Home, Search Equipment, Browse Equipment, Documents, Reports, Administration, and Help. A search bar is present with the text 'Find: Equipment Identifier, Description or SAP Number' and a 'Go' button. The main content area displays the 'Reports' section for 'IPL Health by IPL – Houston Area B - IPL 2'.

**IPL Health by IPL – Houston Area B - IPL 2**

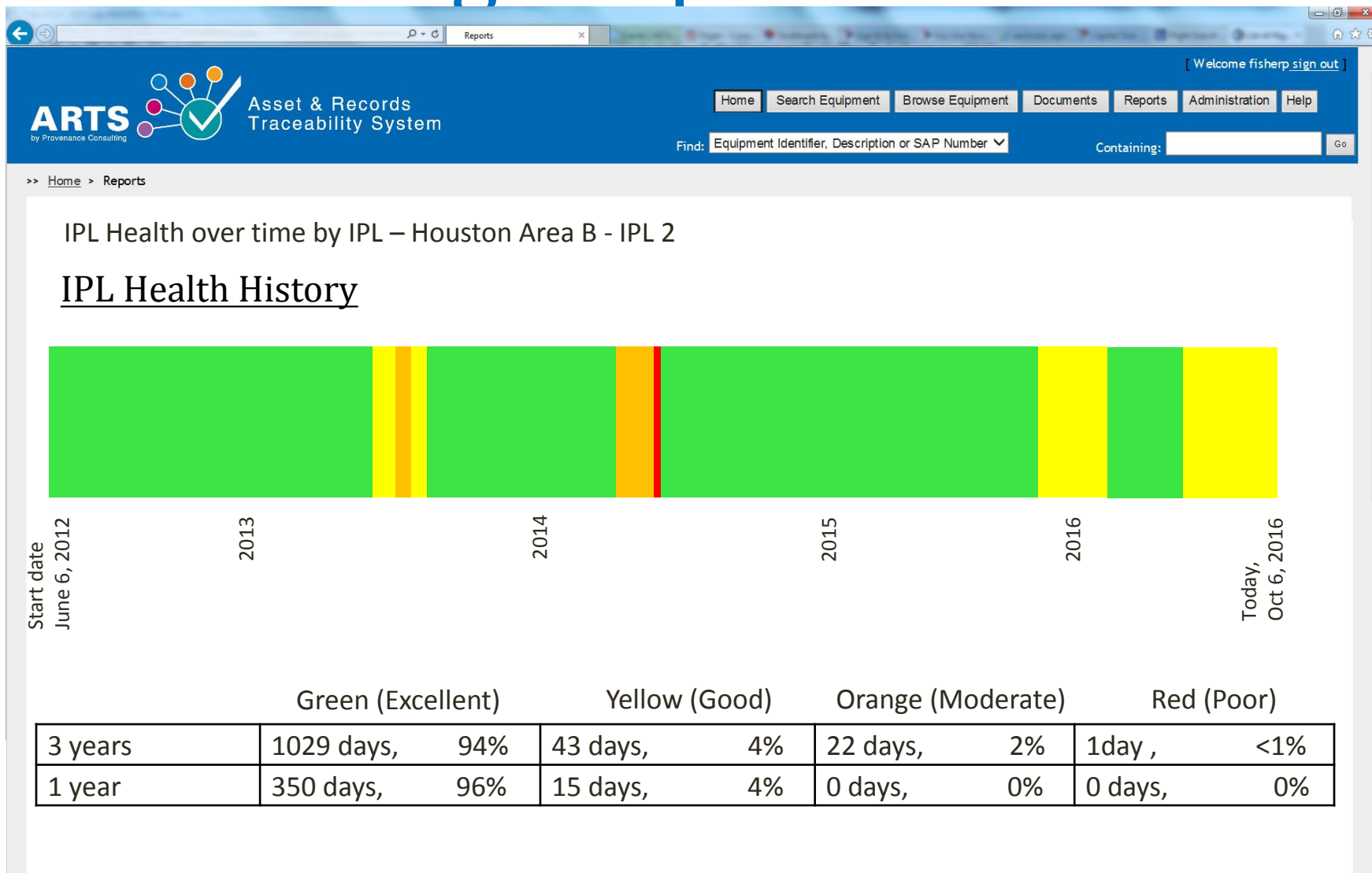
**IPL Description**

PI-101 high pressure alarm, set at 100psig, will alarm through the control system and the Area B board operator will respond within 8 minutes by closing the fuel gas valve HV-102 before the pressure reaches the V-104 MAWP of 120psig.

**Testing**

Component	Design Conditions	PFD	Test Interval	Actual Conditions	Last Test
PT 101	Clean, low vibration	0.1	3 years	Clean, low vibration	3.5 years
I/O Card 856	Instrument enclosure	0.1	3 years	Instrument enclosure	3.5 years
CPU 927	Instrument enclosure	0.01	3 years	Instrument enclosure	2 years
I/O Card 639	Instrument enclosure	0.1	3 years	Instrument enclosure	3.5 years
Logic block 827	N/A	0.1	3 years	N/A	3.5 years
Screen 21	Meets HF standard RS	0.01	1 year	Meets HF standard RS	6 months
HV-102	Clean, low vibration	0.1	3 years	Clean, high vibration	2 years
HV-102 Solenoid	Clean, low vibration	0.1	3 years	Clean, high vibration	2 years
Area B Board operator	Low stress, non-fatigued	0.01	1 year refresher	Low stress, non-fatigued	6 months
Area A/B Instrument Tech	Low stress, non-fatigued	0.1	1 year refresher	Low stress, non-fatigued	6 months

# Recording IPL performance



# Wrapping up

What is an IPL?

*An IPL is a safeguard that can be proven to be effective*

How do we prove an IPL is reliable?

*Document and implement the seven criteria for IPLs*

How do you manage an IPL lifecycle?

*Monitor the documentation and implementation of the IPLs.*



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