AIHS Australian Institute of Health & Safety

Mechanical Plant

Core Body of Knowledge for the
Generalist OHS Professional

Second Edition, 2019

28

Australian OHS Education Accreditation Board

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OHS Body of Knowledge

Summary of update

- **Second Edition published in 2020**
- This second edition has been updated to reflect changes in legislation and standards and the impact of technology on hazards and risk associated with mechanical plant.
- Increase in robotics and industrial automation.
- Updates in AS/NZS4024 Safety of machinery, which has adopted a number of ISO/IEC/EN Standards in the safety related parts of control systems and functional safety systems.

Robotics and Automation

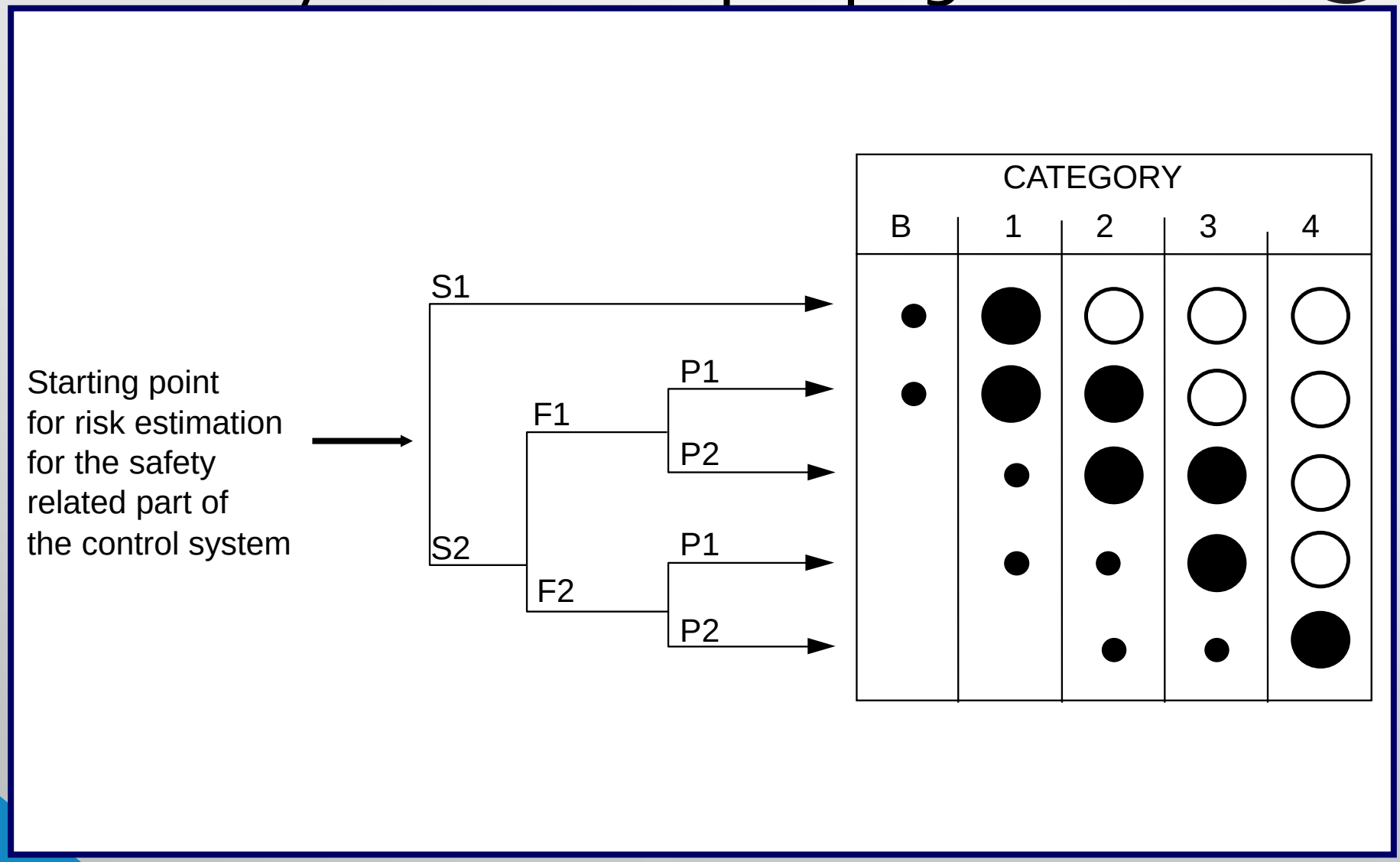
- Whilst the increasing use of robotics and industrial automation reduces the frequency of exposure to the hazards, the reliability of the safety system has to be assessed to ensure it is appropriate for the level of risks.
- AS/NZS4024.1501 provides a qualitative assessment to determine the appropriate Category of control system
- AS.NZS4024.1503 provides a probabilistic assessment to determine the appropriate Performance Level of control system
- AS62061 provides a functional safety assessment to determine the appropriate Safety Integrity Level (SIL) of control systems for complex electronics such as SafetyPLCs.

AS/NZS 4024.1501

- Part 1501 provides a specific assessment method to select the appropriate category for the SRP/CS. Examples of SRP/CS are emergency stop controls, interlocked guards and presence sensing systems.

- Part of a control system which responds to inputs signals and generates safety-related output signals

Summary of AS/NZS4024.1501



Part 1501

LEGEND

S Severity of injury
S1, Slight (normally reversible)injury
S2, Serious (normally irreversible) injury, including death

F Frequency of exposure and/or exposure time to the hazard
F1, Seldom to quite often and/or the exposure time is short
F2, Frequent to continuous and/or the exposure time is long

P Possibility of avoiding the hazard
P1, Possible under specific conditions
P2, Scarcely possible

B, 1 - 4, categories for safety related parts of control systems (See Table 2 of EN954.1 or T able 10.3 of AS 4024 for details)

● Preferred

• Possible categories which require additional measures

○ Overdimensioned

Part 1501

Summary of Categories

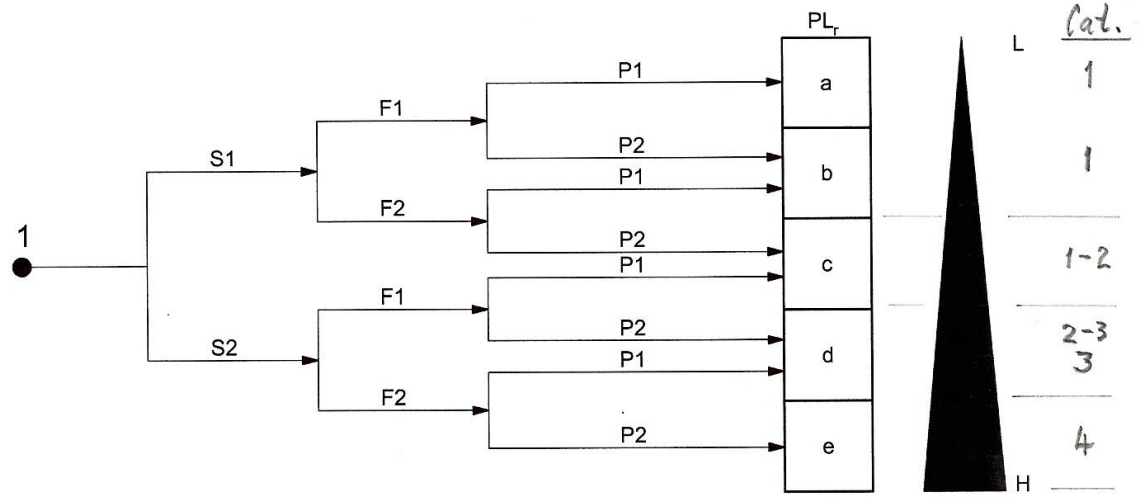
- Cat. B: Designed to meet operational needs only. A single fault can lead to loss of safety function.
- Cat. 1: Relies on well tried principles. A single fault can lead to a loss of safety function.
- Cat. 2: The single fault is checked at suitable intervals.
- Cat.3: Single fault, safety function will still perform.
- Cat.4: Accumulation of fault, safety function will still perform.

AS/NZS 4024.1503

- Part 1503 provides a specific assessment method for determining the required Performance Level (PL) for safety function

- Performance Level (PL) is a discrete level used to specify the ability of safety related parts of control systems to perform a safety function under foreseeable conditions

ISO 13849-1:2006(E)



Key

1 starting point for evaluation of safety function's contribution to risk reduction
L low contribution to risk reduction
H high contribution to risk reduction
PL_r required performance level

Risk parameters:

S severity of injury
S1 slight (normally reversible injury)
S2 serious (normally irreversible injury or death)
F frequency and/or exposure to hazard
F1 seldom-to-less-often and/or exposure time is short
F2 frequent-to-continuous and/or exposure time is long
P possibility of avoiding hazard or limiting harm
P1 possible under specific conditions
P2 scarcely possible

Figure A.1 — Risk graph for determining required PL_r for safety function

Part 1503: SRP/CS (Performance Levels)

Table 3 — Performance levels (PL)

PL	Average probability of dangerous failure per hour 1/h
a	$\geq 10^{-5}$ to $< 10^{-4}$
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$
c	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$
d	$\geq 10^{-7}$ to $< 10^{-6}$
e	$\geq 10^{-8}$ to $< 10^{-7}$
NOTE Besides the average probability of dangerous failure per hour other measures are also necessary to achieve the PL.	

Determination of PL

$MTTF_d$

L:3-10 yrs

M: 10-30yrs

H: 30-100yrs

(Table 5)

DC

N: -60%

L: 60-90%

M: 90-99%

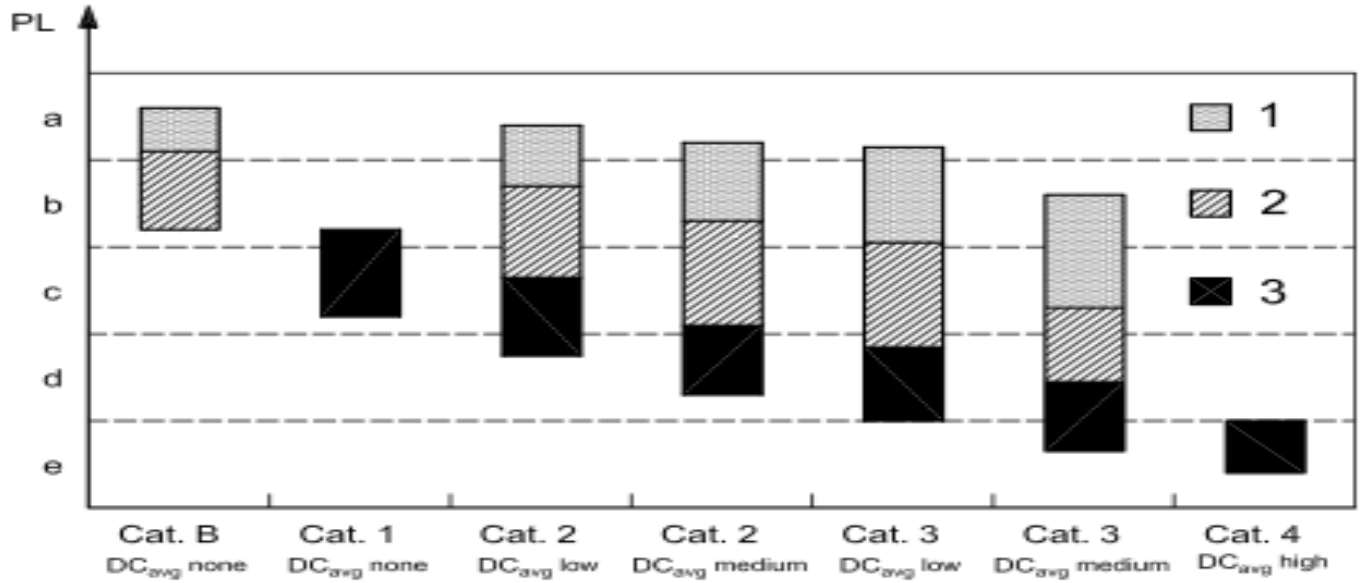
H:99%

(Table 6)

CCF

Above 65

(Table F1)



Key

PL performance level
1 $MTTF_d$ of each channel = low
2 $MTTF_d$ of each channel = medium
3 $MTTF_d$ of each channel = high

Figure 5 — Relationship between categories, DC_{avg}, $MTTF_d$ of each channel and PL

Table 7 — Simplified procedure for evaluating PL achieved by SRP/CS

Category	B	1	2	2	3	3	4
DC_{avg}	none	none	low	medium	low	medium	high
$MTTF_d$ of each channel							
Low	a	Not covered	a	b	b	c	Not covered
Medium	b	Not covered	b	c	c	d	Not covered
High	Not covered	c	c	d	d	d	e

AS 62061 Functional safety of safety- related electrical, electronic and programmable electronic control systems

Table A.6 – SIL assignment matrix

Severity (Se)	Class (Cl)				
	4	5-7	8-10	11-13	14-15
4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3
3		(OM)	SIL 1	SIL 2	SIL 3
2			(OM)	SIL 1	SIL 2
1				(OM)	SIL 1

EXAMPLE: For a specific hazard with an Se assigned as 3, an Fr as 4, an Pr as 5 and an Av as 5 then:

$$Cl = Fr + Pr + Av = 4 + 5 + 5 = 14$$

Using Table A.6, this would lead to a SIL 3 being assigned to the SRCF that is intended to mitigate against the specific hazard.

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Table A.1 – Severity (Se) classification

Consequences	Severity (Se)
Irreversible: death, losing an eye or arm	4
Irreversible: broken limb(s), losing a finger(s)	3
Reversible: requiring attention from a medical practitioner	2
Reversible: requiring first aid	1

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Table A.2– Frequency and duration of exposure (Fr) classification

Frequency and duration of exposure (Fr)	
Frequency of exposure	Frequency, Fr (see A.2.4.1)
≥ 1 per h	5
< 1 per h to ≥ 1 per day	5
< 1 per day to ≥ 1 per 2 weeks	4
< 1 per 2 weeks to ≥ 1 per year	3
< 1 per year	2

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Table A.3– Probability (Pr) classification

Probability of occurrence	Probability (Pr)
Very high	5
Likely	4
Possible	3
Rarely	2
Negligible	1

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Table A.4– Probability of avoiding or limiting harm (Av) classification

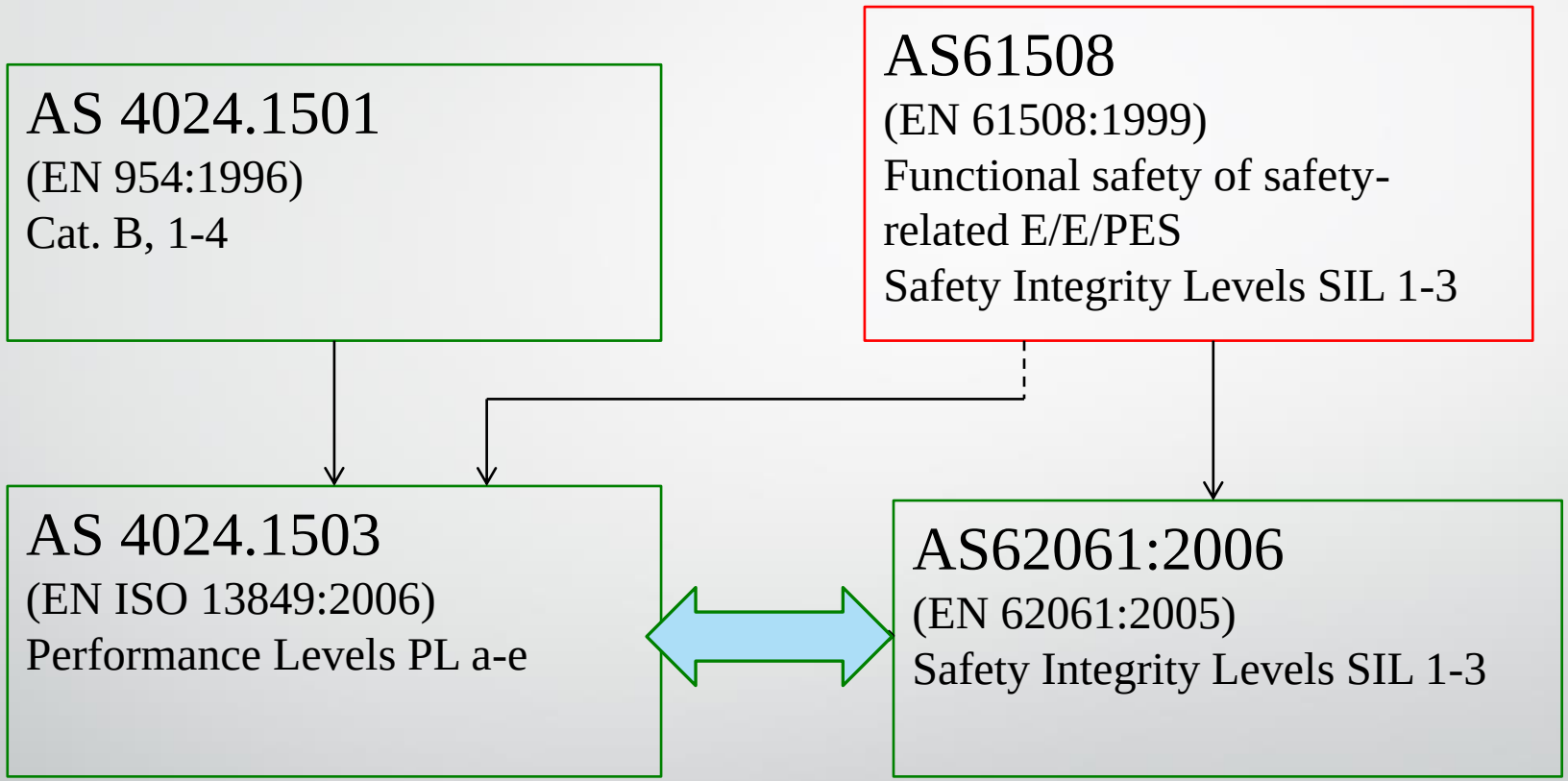
Probabilities of avoiding or limiting harm (AV)	
Impossible	5
Rarely	3
Probable	1

AS/NZS 62061

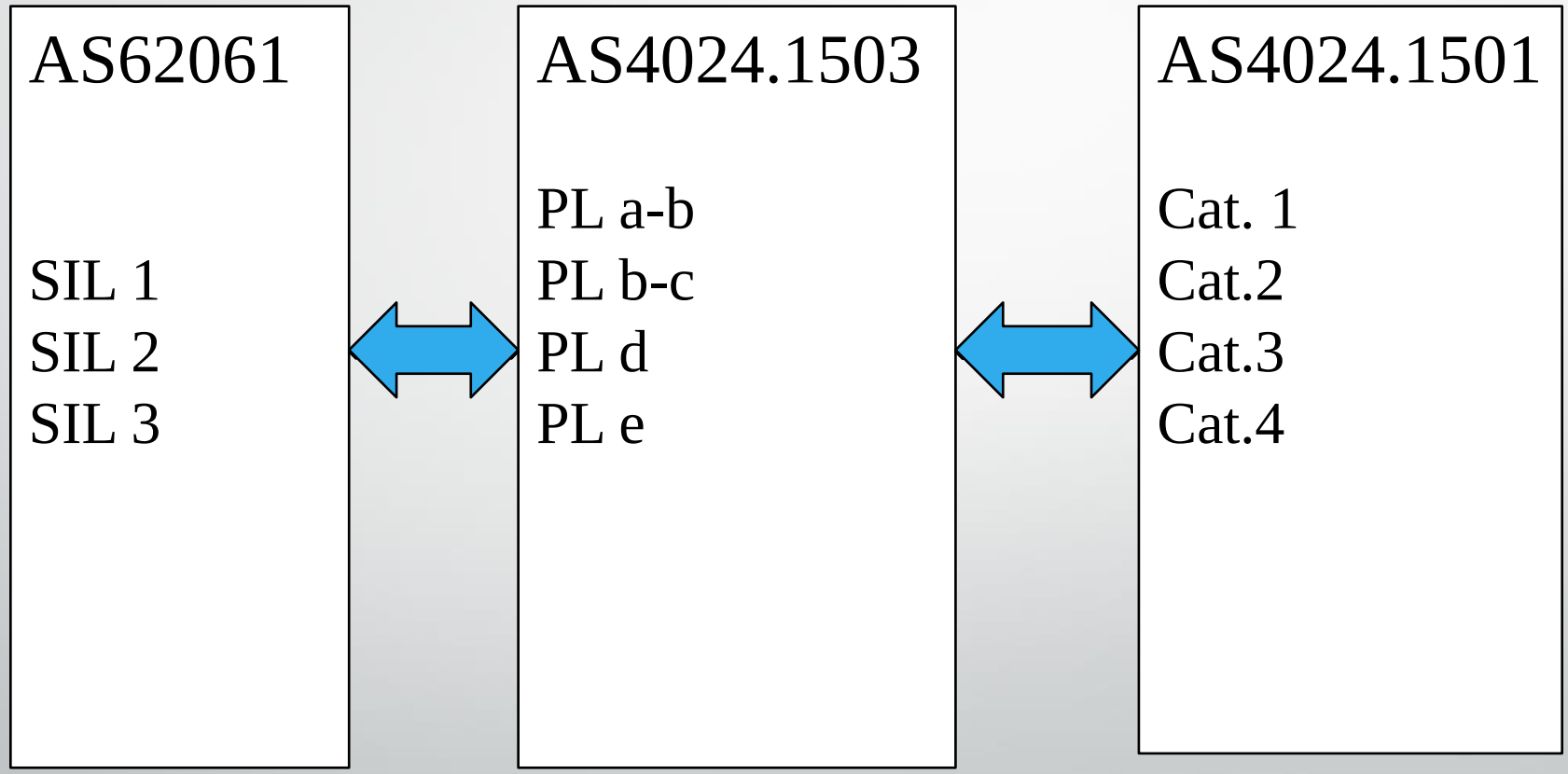
- Example for a typical industrial robot –

- Using AS4024.1501
  - S2F1P2=cat. 2-3 for operator access,
  - S2F2P1=Cat. 3 for programmer access
  - Therefore, a Cat. 3 control system (equivalent to PL d) is applicable (as recommended in AS4024.3301
- Using AS62061
  - S4F4L3P3 = SIL 2 (equivalent to Cat. 3/PL d)
  - Safety PLCs are normally certified to SIL 3 but interfaced through PL d VSDs by stopping the robot by the "safe-toque off"

Standards for SRP/CS



Equivalent ratings (Not identical)



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OHS Body of Knowledge

Energy Isolation

- Major intervention access requiring zero energy LOTO
- Minor intervention access using control energy isolation

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SAMPLE

Rev.No.	Developed By:	Approved By:	Date	DR No.
0				
1				
2				
3				

ENERGY CONTROL & ISOLATION POINTS GUIDE

Plant Description:	**Palletiser**
Location:	Packing Hall

Total number of isolation points: 3

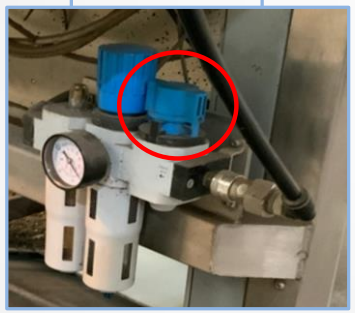
Category of Control System: Cat.3 / PL_d

CAUTION

Mechanical restraint required before access under raised hoist.

Electrical Control Cabinet
Main Electrical Isolator
E-1

Pneumatic Isolator
P-1



Gravitational energy under raised hoist
Fit clear labelling requiring use of mechanical restraint. G-1

ALWAYS SHUT DOWN THE MACHINE BEFORE ENERGY ISOLATION AND LOCKOUT

ID	Source	Device	Location	Lock Out Method &/or Releasing Energy	Check Procedure
E - 1	ELECTRICAL	Padlock	Located on the front of the main electrical cabinet next to the operator control panel.	Turn isolating switch to OFF Apply tag & personal padlock. If possible ensure production data is collected before switching machine off	Power Indicator Light on Main Control Verify machine will not start from controls
P - 1	PNEUMATIC - AIR	Padlock	Located on the eastern side next to the empy pallet hoist.	Turn isolating valve to CLOSED and release any trapped air Apply tag & personal padlock.	Observe pressure gauge reads zero and attempt to operate the manual product push arm. Confirm the push arm does not operate.
G - 1	GRAVITY	Mechanical bars	Fit labels to identify storage of bars and location to insert bars.	Insert mechanical support.	Observe mechanical pins position switch indicating light is illuminated.

DANGER

<< any other safety message here >>

Safety is Your Responsibility

DANGER

LOTO EXCEMPTION (Allowed Minor Interventions for Cat.3 / PL_d control system)

Exceptions of LOTO are permitted when accessing through interlocked gates and light guards when:

- Clearing of minor jams (less than 10 minutes)
- Minor adjustments
- Spot cleaning of electronic eyes of other sensors
- Straightening products
- Minor surface cleaning (excludes cleaning under machine)

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IF IN DOUBT, LOCK IT OUT

Summary

AS4024 series is a continuing evolving series of standards, adopting (or modified text adoption) international ISO/IEC/EN Standards for safety of machinery.