

HUMAN ERROR LIMITS SIL RATING

EQUATIONS

$$PFD_{SIF} = PFD_S + PFD_{LS} + PFD_{FE} + PFD_{SS} + PFD_{SYS}$$

$$PFD_{SYS} = P_{error\ design} + P_{error\ installation} + P_{error\ proof\ test} + P_{error\ calibration} + P_{error\ bypassed}$$

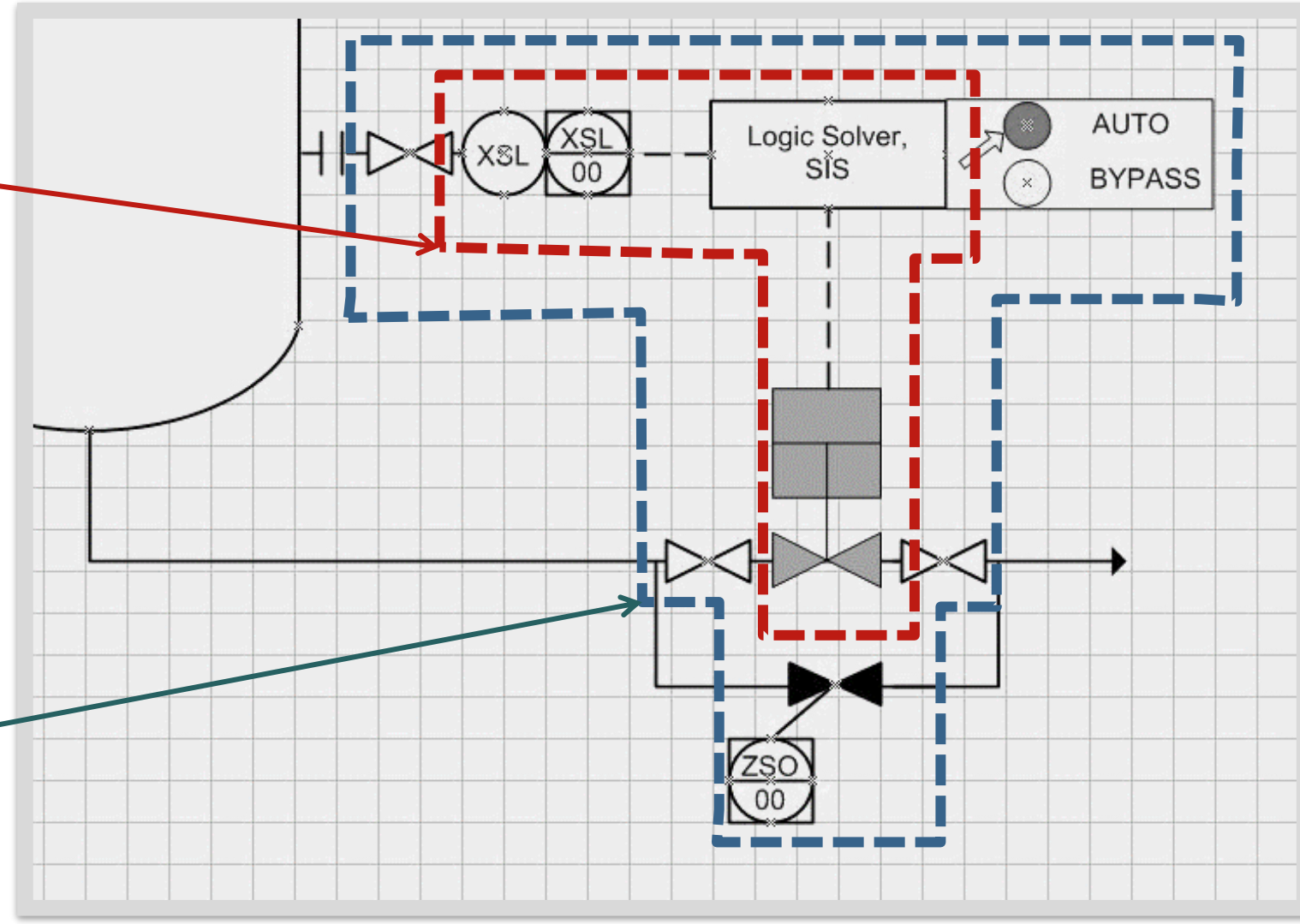
Detect and correct during commissioning
P_{HUM}: Human error during operation and maintenance

$$PFD_{SIF} = PFD_S + PFD_{LS} + PFD_{FE} + PFD_{SS} + PFD_{HUM}$$

SIF BOUNDARY

Boundary A: Instrumented components only
(most SIL verifications use this boundary)

Boundary B: Complete IPL
(includes root valves and bypasses)



HE LOWER LIMITS*

* Assumes no time dependent

1/100 Process industry; routine tasks performed 1/month to 1/year. Assumes excellent control of all human factors

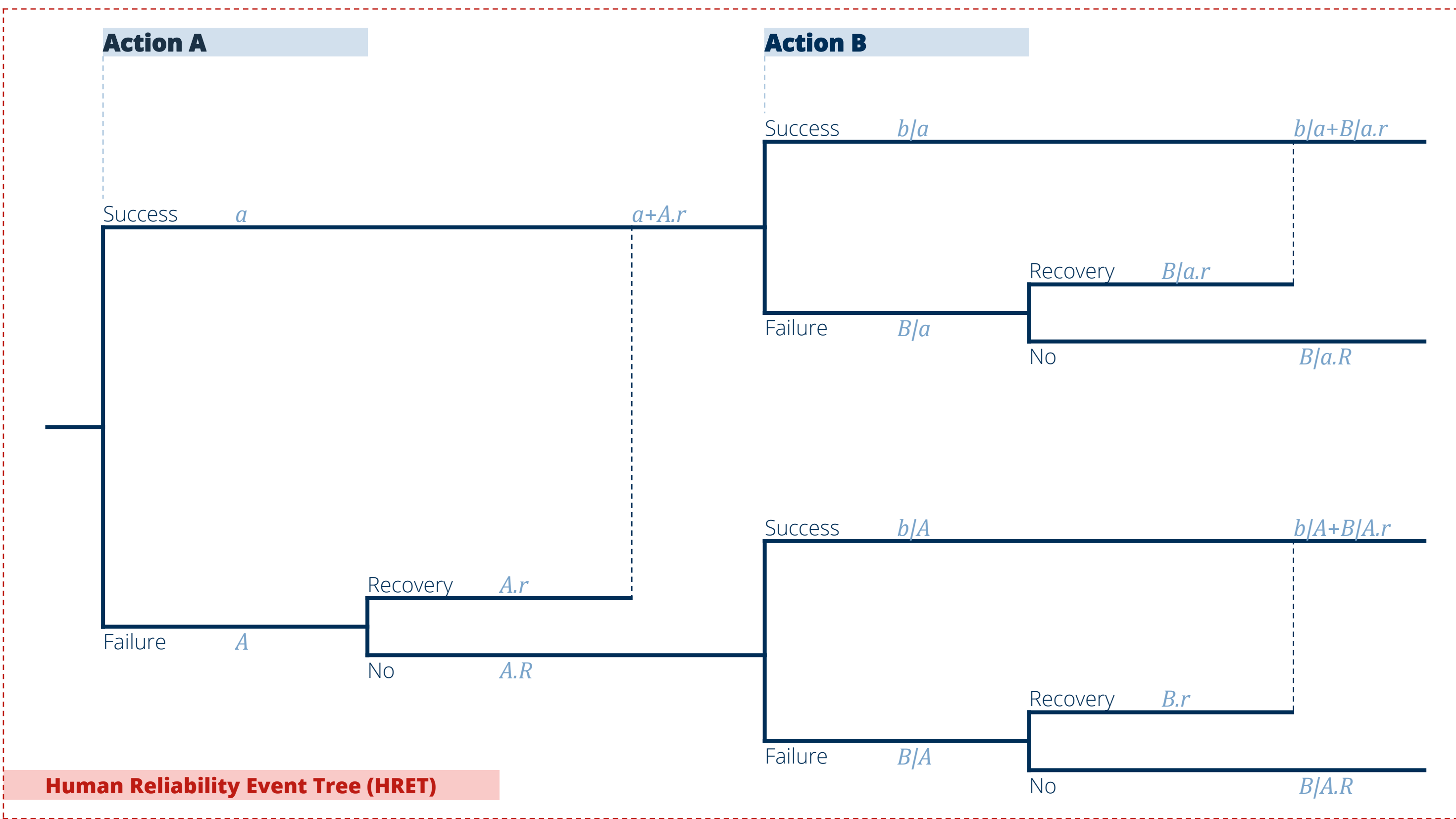
1/200 Pilots in the airline industry; routine tasks performed multiple times a day with excellent control of human factors

1/1000 Process industry; routine tasks performed several times per day. Assumes excellent control of human factors. Also for a reflex action, such as either proactive or minor corrective actions while driving a car.

HUMAN FACTORS

Category	Issue/Level	Multiplier
Stress	Extreme	5
	High	2
	Nominal	1
Complexity & Task Design	Highly complex	5
	Moderately complex (requires more than one staff)	2
	Nominal	1
Experience/ Training	Obvious diagnosis	0.1
	Low	10
	Nominal	1
Procedures	High	0.5
	Not available in the field as a reference, but should be	20
	Incomplete; missing this task or these steps	10
Human-Machine Interface	Available and >90% accurate, but does not follow format rules	5
	Good, 95% accurate, follows >90% of format rules	0.5
	Diagnostic/symptom oriented	1
Fitness for duty	Missing/Misleading	20
	Poor or hard to find the right device; in the head calc	10
	Some unclear labels or displays	1
Work Processes & Supervision	Good	0.5
	Unfit - High fatigue level (>80 hr/week or >20 hr/day, no day off in 7-day period; or illness, etc.)	20
	Highly degraded fitness (high fatigue such as >15 hr/day, illness, injury, etc.)	10
Work environment	Degraded Fitness (>12 hr day and >72 hr/week)	5
	Slight fatigue (>8 hr per day; normal value for process industry)	2
	Nominal	1
Communication	Poor	2
	Nominal	1
	Good	0.8
Communication	Extreme	5
	Good	1
	No communication or system interference/damage	10
Communication	No standard for verbal communication rules (normal value for process industry)	5
	Well implemented and practiced standard	1

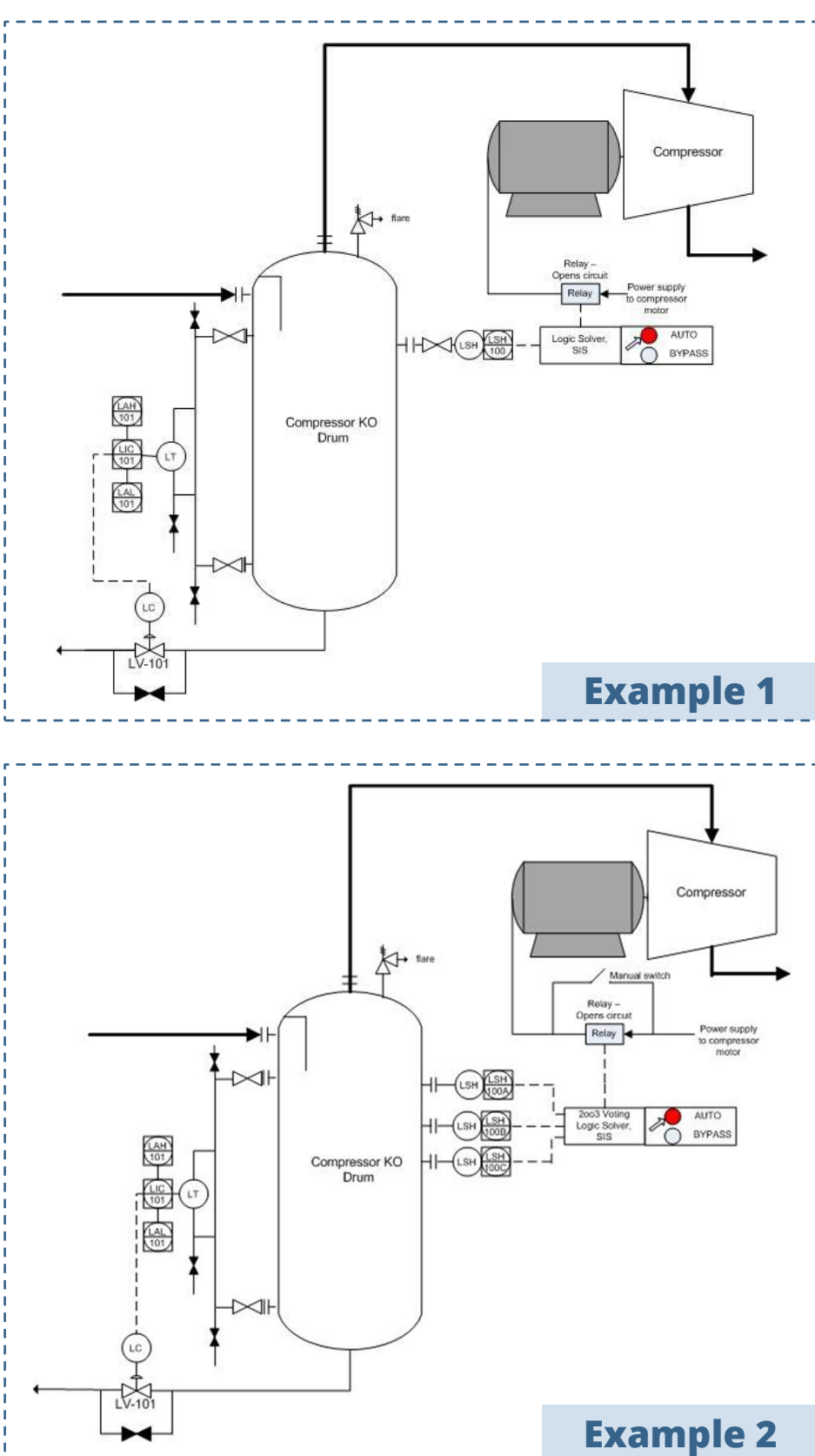
HUMAN ERROR DEPENDENCY



Level of dependence	Same person?	Actions close in time?	Same visual frame of reference?	Worker required to write something for each component?
Zero (ZD)	No	Yes/No	Yes/No	Yes/No
Zero (ZD)	Yes	No. Separated by several days.	Yes/No	Yes/No
Low (LD)	Yes	Low. Similar tasks performed on sequential days	No	Yes
Moderate (MD)	Yes	Moderate. Similar tasks performed more than 4h apart	No	No
High (HD)	Yes	Yes. Similar tasks are performed within 2h.	No	No
Complete (CD)	Yes	Yes. Similar tasks are performed within 2h.	Yes	Yes/No

Level of dependence	Success @N given Success @N-1	Failure @N given Failure @N-1
Zero (ZD)	$P_{Success@N} = 1 - HEP_N$	$P_{Failure@N} = HEP_N$
Low (LD)	$P_{Success@N} = [1 + 19 \times (1 - HEP_N)]/20$	$P_{Failure@N} = [1 + 19 \times HEP_N]/20$
Moderate (MD)	$P_{Success@N} = [1 + 6 \times (1 - HEP_N)]/7$	$P_{Failure@N} = [1 + 6 \times HEP_N]/7$
High (HD)	$P_{Success@N} = [1 + (1 - HEP_N)]/2$	$P_{Failure@N} = [1 + HEP_N]/2$
Complete (CD)	$P_{Success@N} = 1$	$P_{Failure@N} = 1$

EXAMPLES



Ex #	Baseline HEP	Target SIL	PDF Comp	Achieved SIL per 61511	Maint.	PFD for Human Errors				Total PFD SYS-HUM	Achieved PFD SIF per CCPS	Achieved SIL per CCPS	Detect and Recovery from Error				
						PFD Root Valves	PFD SIF Bypass	PFD Relay bypass	PFD Miscali				Detect & correct error	PFD Change	Total PFD SYS-HUM	Achieved PFD SIF per CCPS, Rev	Achieved SIL per CCPS, Rev
1	0.02	1	0.039	1		0.02	0.02	0.02	0.06	0.0990	1	Root valves	-0.0190	0.0410	0.0800	1	
	0.04	1	0.039	1		0.04	0.04	0.04	0.12	0.1590	1	Root valves	-0.0380	0.0820	0.1210	1	
2	0.02	2	0.008	2	No staggering	0.00522	0.02000	0.02000	0.00522	0.05044	1	Root valves	-0.00496	0.04548	0.05348	1	
	0.02	2	0.008	2	Staggering	0.00010	0.02000	0.02000	0.00010	0.04019	1	SIF Bypass	-0.01900	0.00219	0.01019	2	
2 High Practice	0.0041	2	0.008	2	No staggering	0.00102	0.00410	0.00410	0.00102	0.01024	1	Root valves	-0.00097	0.00927	0.01727	2	
	0.0041	2	0.008	2	Staggering	0.00012	0.00410	0.00410	0.00012	0.00844	2	SIF Bypass	-0.00390	0.00065	0.00865	2	
	0.0041	2	0.008	2	Staggering	0.00012	0.00410	0.00410	0.00012	0.00844	2	Relay bypass	-0.00390	0.00065	0.00865	2	
N/A	0.0041	3	0.0007	3	Staggering	0.00001	0.00410	0.00410	0.00001	0.00822	0.00892	2	SIF Bypass	-0.00390	0.00043	0.00113	3
													Relay bypass	-0.00390			

