A KPI for control valve reliability used in projects with SPI

P2C2 Houston SPI LTUF Meeting

November 15, 2016 ProLytX

The presenter

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  - Active in software development since 1979
  - Developing instrumentation and process design software since 1985
  - Doing engineering services since 2001

Overview

- Common risks on problems in control valve sizing and selection
  - Capex projects
  - Turnarounds
- Solution by predictive reliability analysis
- Lessons learned
  Applying reliability index “Ri” in real life together with SPI

What you'll see and what not

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Control valve	Calculation and optimization especially from the control engineering point of view
Control valve (two phases)	Calculation and optimization of control valves with two-phase flow at the inletsa
Steam conditioning valve	Calculation of the steam conditioning unit including the required cooling water flow
Actuator forces	Calculation of required actuator forces of globe valves
Differential pressure flow element	Flow measurement according to ISO, API and ASME with orifice elements, venturi tubes, nozzles and pitot tubes
Restriction orifice plate	Sizing, adaptation and optimization
Pressure loss	Taking into account the pipe length, individual resistances and elevation differences
Pressure surge	Pressure surge characteristics with variable closing times and different valve characteristics
Sizing	Cross-sectional area, jacket area, flow velocities, Joukowsky peak, etc.
Pipe compensation	Calculation of the changes in length, pipe support loads and compensation (L or U-bend)
Span calculation	Taking into account the dead weight, insulating material and maximum permissible sag
Pipe wall thickness	This calculation according to EN 13480 and DIN 2413 applies to pipes subjected to an internal pressure

What you'll see and what not

Shell-and-tube heat exchangers	Sizing and recalculation of liquid-liquid shell-and-tube heat exchangers from the process engineering point of view
Condenser	Calculation of liquid-cooled condensers
Material data calculation	Computation of the characteristics of tubing and equipment materials
Pressure relief valve	According to AD, ISO, API and ASME, pressure losses and piping forces, two-phase flow
Rupture discs	Calculation of rupture discs according to API 520 and ISO 4126
Thermowells	Calculation of thermowells according to ASME PTC 19.3
Level calibration	Measurement of drum level using a differential pressure transmitter
Tank depressurization	A tank filled with gas is depressurized either into the atmosphere or into a second tank
Pump and compressor output	The motor power requirements of pumps, fans and compressors are determined
Substance calculation	Calculation of pressure and temperature-related properties
Thermodynamics module	Calculate and plot thermophysical properties of substances in the fluid phase
Regression	Graphical representation and adaptation of a curve to a series of measuring points

Control Valve Cost Distribution

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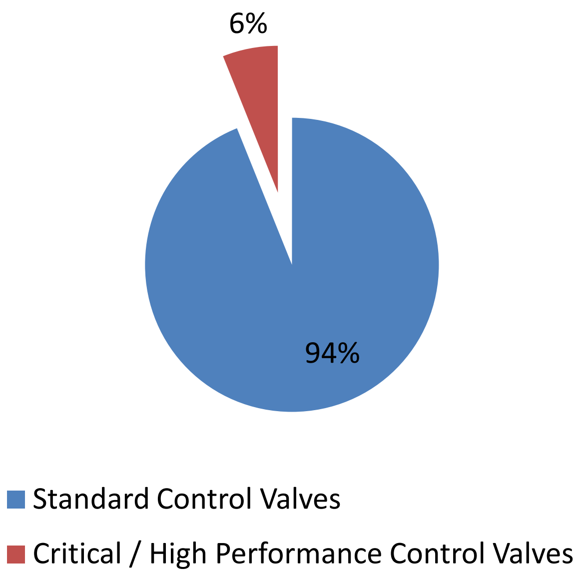
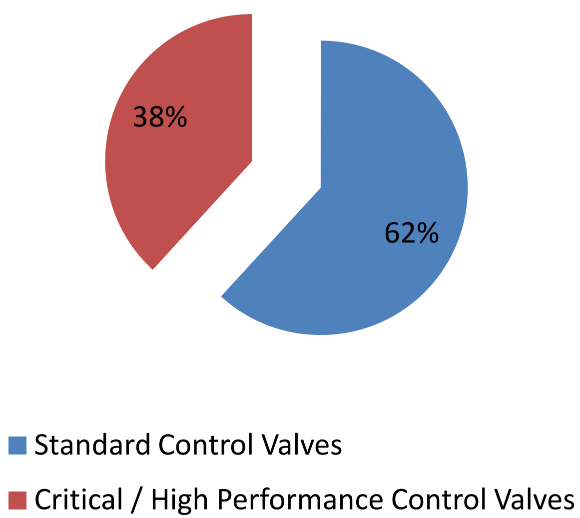
Small number

Number of valves



Big impact on purchase cost

Proportional purchase cost



Scenario: Capex projects

- High performance valves are not fit for the application
- Risk of valves failing during commissioning and startup
- Real example of a Petrochemical plant
  - Major problems with high performance valves
  - >2,5 million $ reengineering and replacement cost
  - Startup delay > 30 days

Scenario: Turnarounds

- Detection of unexpected damages on High Performance Control Valves
- Spare part lead time several month
- Workarounds are introducing further cost
- Risk off project and startup delays

Common to both scenarios

- Root cause analysis necessary
  - Based on the “real” process data (hard to get)
- Reengineering
  - Depending on vendor recommendations for the solution
  - Risk of repeatedly selecting a poor solution
- Replacement
  - Long lead times may impact operation
  - Risk of operation loss

What if…

- you could predict if a Control Valve is
  "fit for the application" at all?
- you could predict reliability problems (e.g. due process data changes) to preorder spare parts for turnarounds.
- you get rating for how good a valve fits to the process conditions to select the best available solution
- you could apply "Ri" on large control valve populations
- you could therefor minimize the risk of capital losses

Control Valve sizing and selection

- Select a valve that
  - works stable in the required range of control
  - give you some reserve on control
  - fulfills its job reliable
- Verify that the selection meets all the requirements
- Don't rely on a vendors recommendation only

Why do we need a KPI?

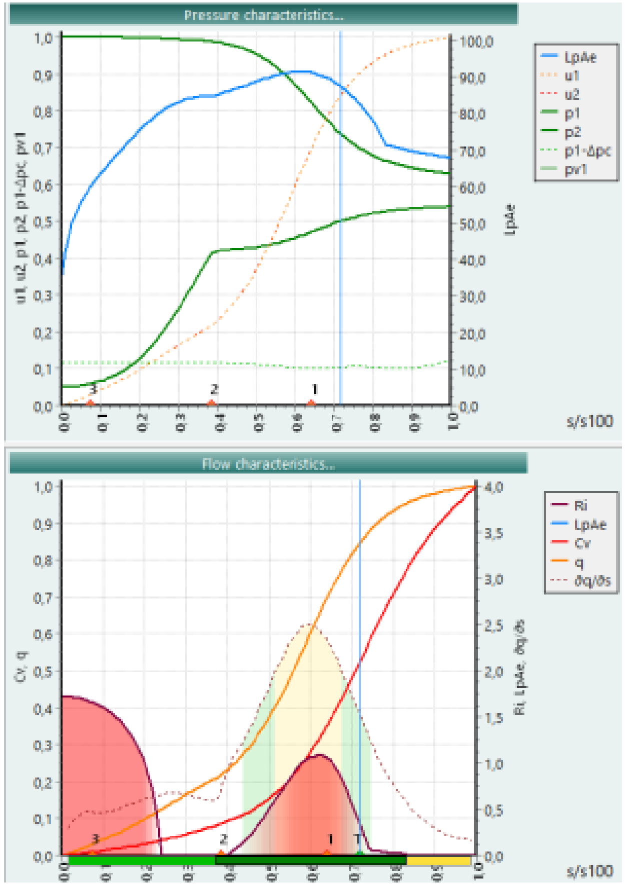
- Are you a valve nerd?
  Some, maybe most of us will answer “For sure not”
- “How can I reproducible decide if a valve matches the given process conditions so that it performs reliable in any mode of operation?”
  - Gut instinct?
  - Rules of thumb?
  - Applying best practices?

Why do we need a KPI?

- Ensure that independent from the individual doing the analysis the given rating is reproducible identical
- Allow analysing valve cases by “non-nerds” having “only” the process conditions
- Quickly detect the severe cases in big number of cases
- To predict the impact of changing process conditions
- …

Why do we need a "Ri" KPI?

- To review the full range of operating conditions:
  (Min, Norm, Max,
  Start-up, …
  0% to 100% of
  valve opening)
- To ensure that you don't miss something



Quick definition of “Ri”

- A single number for each operating / process condition
- The range of the value is defined

– 0	to	0.1	No reliability problems expected
– 0.1	to	0.5	Possible reliability problems
– 0.5	to	1	Limited reliability
– >1			Possible mechanical damage

- Additional info on the root cause and options to improve

Building the "Ri" in brief

- To calculate the "Ri", all major reliability influencing factors need to be taken into account.
- General parameters like
  - Δp
  - Energy conversion
  - Noise level
  - Outlet flow velocity
  - Valve type
- Flow conditions
  - Cavitation
  - Flashing
  - Choked flow
- Fluid properties
- Process conditions
  - Normal operation
  - Start-up
  - Special operation
- …

How to apply a “Ri” in projects?

- Import latest data from SPI and vendor tools
- Determine the “Ri” with final operating conditions for all modes of operation for all control valves
- Follow the hints, discuss and select more suitable solutions
- Ensure that finally no valve will be selected with a “Ri” > 0.1

- Sounds easy, isn’t it?

Challenges applying the "Ri"

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Process data / specification

- Tools involved
  - Process simulators
  - SPI
  - Vendor tools
- One time handover
  - Process Data Sheet
  - Instrument Data Sheet
- Bulk processing

Interfaces involved

- Import from Process Simulator Software
- Import from SPI
  - Process Datasheet
  - Instrument Datasheet
- Import from Vendor tool
  - Fisher First 2
  - Fisher Specification Manager

CONVAL Adapter Tool - CΛT

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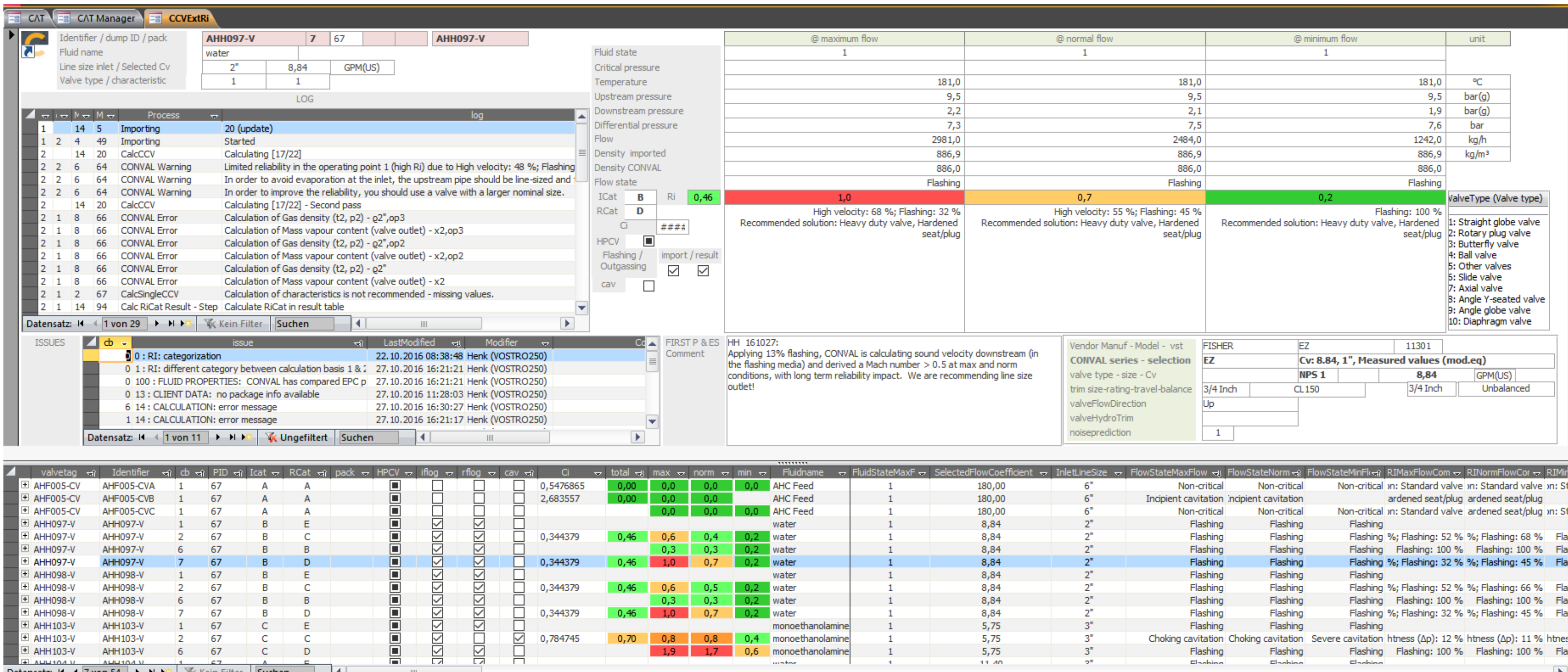
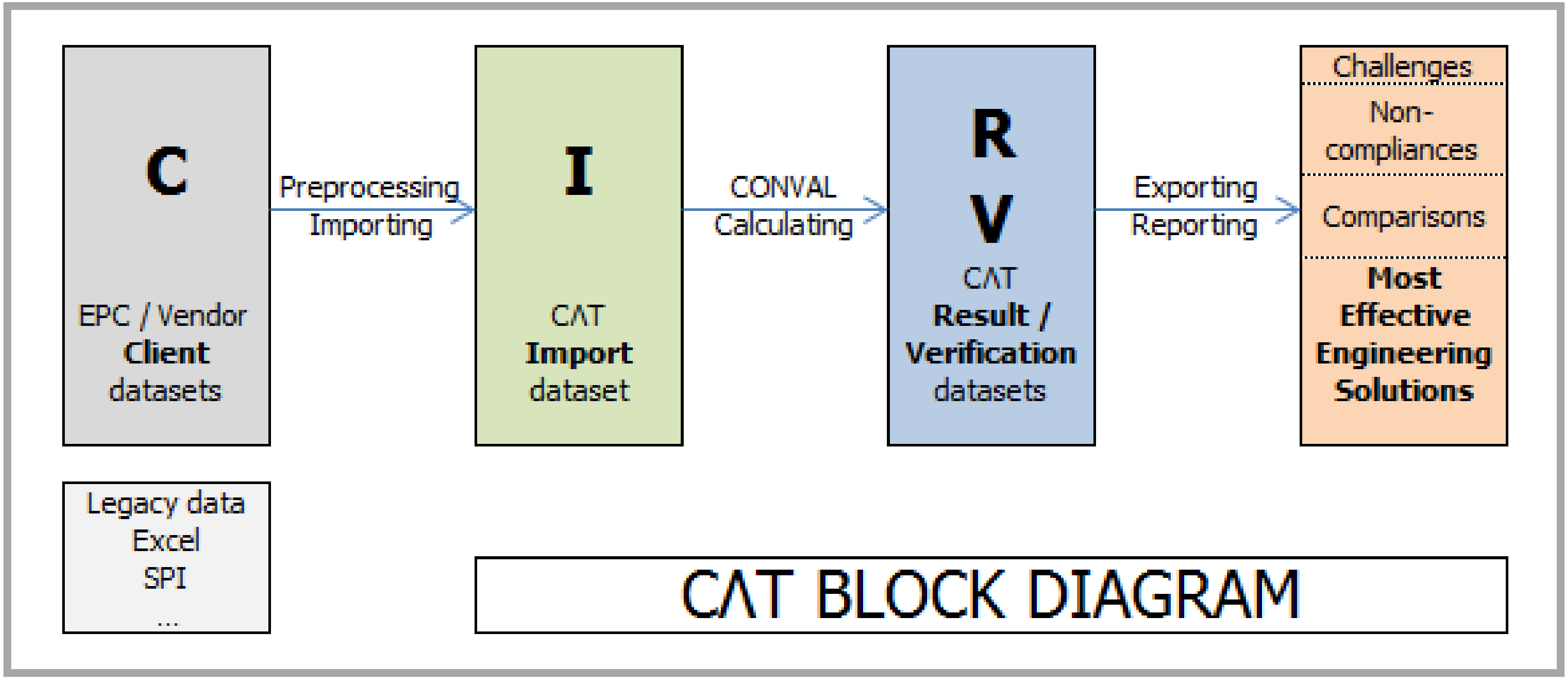


CΛT General processing

CONVΛL by F.I.R.S.T.



CAT Reporting

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26
NAG

CAT Control Valves Verifications - package 1

Monday, 02 March, 2015
18:42:13

* cat: A = Ri<0.1, B = 0.1<Ri<0.5,C = Ri>0.5, D = Ri>1, E = 2-phase
* valve type: C=Client specified, V= Vendor; 1= Globe, 2=Rotary, 3=Butterfly, 4=Ball, 5=Other, 6=Slide, 7=Axial, 8=Angle Y, 9=Angle globe, 10=Diaphragm
* DNr = ratio suggested DN / vendor DN ; if >1 warning, if > 2 issue!

Identifier	Ricat	Ri tot - max - norm - min					observations from CONVAL calculation(s)	Reliabilty influencing factors
series + trim					DN	Cv100	observations from vendor documentation	CONVAL recommended solution
pack	valv type C/V	page		cage?	DNr	found	analysis	

ISSUE(s)	RECOMMENDATION

28FV3102	D		11.3	14.0	5.7	3.0	SPL 124/105/96.1 Db(A)	Cavitation damage: 3.8 %; Sound pressure level: 85 %; High velocity: 11 %
V260B		Full bore			12"	2400	SPL 96/98/82 dB(A)	Heavy duty valve, Hardened seat/plug, Low-noise
1	4	4	1	☐	2.33	☑	Noise calc: Pressure level correction -20 dB??? ANDREAS?? Ri problem at max flow!	

VALVE SIZE: Conval recommends a larger valve size	Consider a larger valve size
NOISE CALC: High SPL	Consider a lo-noise design
VALVE OUTLET: Valve outlet too small.	Consider larger valve outlet
NOMINAL FLOW COEFF: Cv100 lower than CONVAL suggested minimum flow coefficient	Consider a larger nominal flow coefficient
PIPE SCHEDULE: missing in EPC package. Std assumed. Possible impact on noise calculation!	Assess possible impact on noise calculation
FLUID PROPERTIES: CONVAL has compared EPC properties vs Extended properties data and made 2 cases	Consider using CONVAL extended property data

28PV3112A	E					0.0	SPL 121/121/88.3 Db(A)	Seat tightness (t,P): 100 %
A31A Bfly		:entric reinforce			24"	21500		Heavy duty valve
1	3	3	1	☐	1.00	☑	no issue	

PIPE SCHEDULE: missing in EPC package. Std assumed. Possible impact on noise calculation!	Assess possible impact on noise calculation

28PV3112B	E					0.0	SPL 121/120/87.6 Db(A)	Seat tightness (t,P): 100 %
A31A Bfly		:entric reinforce			24"	21500		Heavy duty valve
1	3	3	1	☐	1.00	☑	no issue	

PIPE SCHEDULE: missing in EPC package. Std assumed. Possible impact on noise calculation!	Assess possible impact on noise calculation

30PV3208A	D			2.9	1.2	0.0	SPL 111/104/99.6 Db(A)	Sound pressure level: 40 %; Power loss: 60 %
EUD/EUT Whisper trim		Multihole trim			16"	2095	SPL 95/92/84 dB(A) ; XS schedule!	Special valve, Hardened seat/plug, Low-noise
1	1	1	1	☑	1.25	☑	Impact downstream schedule on noise calculation ; Impact N0 # flow passages! (AV?) used 500?	

FLUID PROPERTIES: CONVAL has compared EPC properties vs Extended properties data and made 2 cases	Consider using CONVAL extended property data
VALVE PERFORMANCE CLASS: Conval recommends a special valve.	Vendor to confirm that selected valve can handle the power dissipation
VALVE OUTLET: Valve outlet too small.	Consider larger valve outlet
NOISE CALC: High SPL	Consider a lo-noise design
NOMINAL FLOW COEFF: Cv100 lower than CONVAL suggested minimum flow coefficient	Consider a larger nominal flow coefficient
PIPE SCHEDULE: missing in EPC package. Std assumed. Possible impact on noise calculation!	Assess possible impact on noise calculation

Page 1 of 3

CΛT Verification issues statistics

CONVAL® by F.I.R.S.T.

26		
NAG		
package	1	

CΛT control valves verifications issues statistics

Monday, 02 March, 2015
19:32:48

* cat: A = Ri<0.1, B = 0.1<Ri<0.5 ,C = Ri>0.5, D = Ri>1, E = 2-phase
* valve type: C=Client specified, V= Vendor; 1= Globe, 2=Rotary, 3=Butterfly, 4=Ball, 5=Other, 6=Slide, 7=Axial, 8=Angle Y, 9=Angle globe, 10=Diaphragm
* I = Issue, R = Recommendation, C = comments

I : FLUID PHASE: Conval cannot predict reliability for 2-phase flow
R : CURRENTLY CAN'T RECOMMEND (CONVAL 10 DEVELOPMENT)
C : 2-phase flow if liquid content is larger than 5%

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
36HV4139	1	E	3	3	FISHER	A11		23800	30"	1

I : FLUID PROPERTIES: CONVAL has compared EPC properties vs Extended properties data and made 2 cases
R : Consider using CONVAL extended property data
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
92LV4002	1	D	1	4	FISHER	V150	Segmented ball	5200	14"	1
80PV4404	1	B	3	3	FISHER	A31A Bfly	Centric reinforced	11050	18"	1
46XV5131	1	C	9	1	FISHER	EWD	Cage trim	924	10"	1
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

I : MACH NUMBER: Ma in valve outlet too high
R : Consider a redesign
C : Ma > 1

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1

I : NOISE CALC: Conval yields a substantial higher SPL (sound pressure level) according to latest IEC 60534-8-4
R : Consider a lo-noise design
C : Substantial if a higher than 10 db(A) difference between CONVAL and vendor calculation

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
92LV4002	1	D	1	4	FISHER	V150	Segmented ball	5200	14"	1

I : NOISE CALC: High SPL
R : Consider a lo-noise design
C : Conval creating a warning

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
92LV4002	1	D	1	4	FISHER	V150	Segmented ball	5200	14"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

I : NOMINAL FLOW COEFF: Cv100 lower than CONVAL suggested minimum flow coefficient
R : Consider a larger nominal flow coefficient
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

Page 1 of 3

I : PIPE SCHEDULE: missing in EPC package. Std assumed. Possible impact on noise calculation!
R : Assess possible impact on noise calculation
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
92LV4002	1	D	1	4	FISHER	V150	Segmented ball	5200	14"	1
80PV4404	1	B	3	3	FISHER	A31A Bfly	Centric reinforced	11050	18"	1
46XV5131	1	C	9	1	FISHER	EWD	Cage trim	924	10"	1
41FV4520	1	C	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2049	16"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1
28PV3112B	1	E	3	3	FISHER	A31A Bfly	Centric reinforced	21500	24"	1
28PV3112A	1	E	3	3	FISHER	A31A Bfly	Centric reinforced	21500	24"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

I : PROCESS DATA: flow zero at a given working point
R : EPC to supply us correct/missing process data
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
80PV4404	1	B	3	3	FISHER	A31A Bfly	Centric reinforced	11050	18"	1
46XV5131	1	C	9	1	FISHER	EWD	Cage trim	924	10"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1

I : VALVE DBASE: Valve missing in Conval vendor valve database
R : EPC to provide us with vendor specific valve data
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
36HV4139	1	E	3	3	FISHER	A11		23800	30"	1

I : VALVE OUTLET: Valve outlet too small.
R : Consider larger valve outlet
C :

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
93FV1002	1	D	1	4	FISHER	V150	Segmented ball	3340	14"	1
46XV5131	1	C	9	1	FISHER	EWD	Cage trim	924	10"	1
41FV4520	1	C	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2049	16"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

I : VALVE PERFORMANCE CLASS: Conval recommends a special valve.
R : Vendor to confirm that selected valve can handle the power dissipation
C :

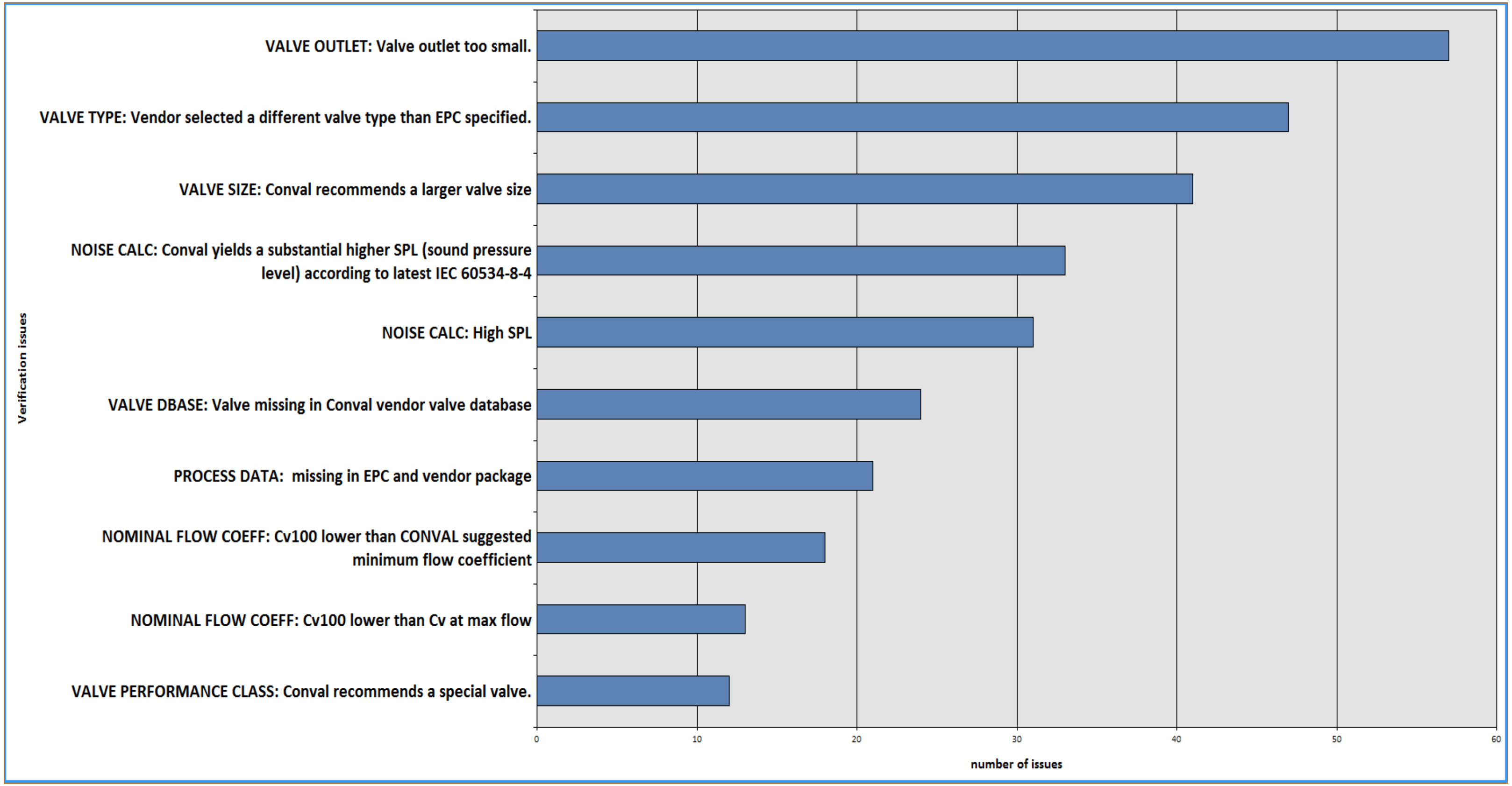
Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
41FV4520	1	C	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2049	16"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1
30PV3208A	1	D	1	1	FISHER	EUD/EUT Whisper trim	Multihole trim	2095	16"	1

I : VALVE SIZE: Conval recommends a larger valve size
R : Consider a larger valve size
C : directly impacts outlet velocity as visualized by DNr (DN ratio)> 1.25!

Identifier	pack	cat	valve type C/V		manufacturer	series	trim	Cv 100	DN	page
46XV5131	1	C	9	1	FISHER	EWD	Cage trim	924	10"	1
39PV4304	1		1	1	FISHER	EWD Whisper trim I	Contoured plug	883	16"	1
31PV3307	1	D	3	1	FISHER	ET Whisper trim III	Multihole trim	1315	12"	1
28FV3102	1	D	4	4	FISHER	V260B	Full bore	2400	12"	1

Page 2 of 3

CAT issues pareto chart



Challenges applying the “Ri”

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Data contend

- Data not complete
- Data not correct
- Data changing last minute
- Data not covering all modes of operation (e.g. Start-up)

Data format

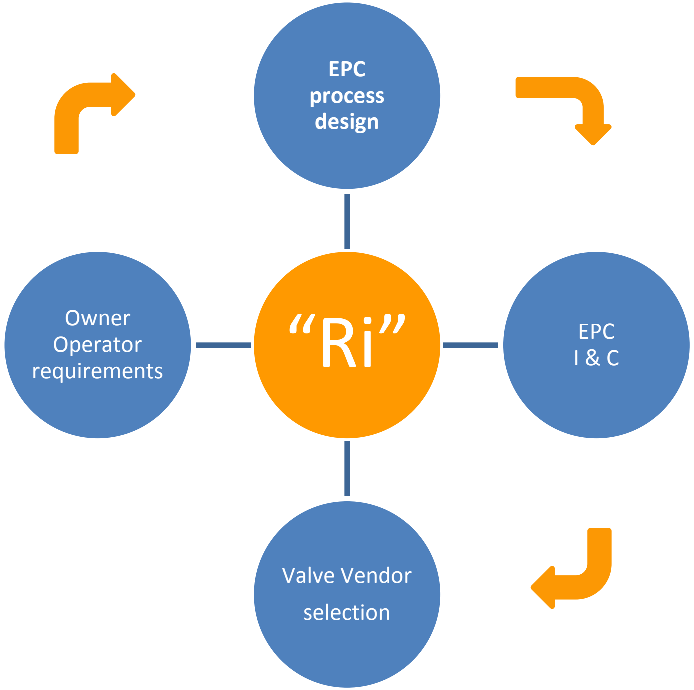
- Data structure specification not consistent
- Data not structured (e.g. Notes)
- Flashing / Outgassing data in SPI process datasheet
- Lots of relevant data un UDFs

Special challenges in projects

Communication

- The biggest challenge at all
- 3+ parties involved
- Project workflow is not yet designed to use a "Ri" as a central quality control element
- There is no common data language for cycling specification and selection data
- No common practice established yet

Collaboration



Q&A / Discussion