National Nuclear Security Administration (NNSA)

Defense Nuclear Nonproliferation (DNN)

U.S. High Performance Research Reactor (USHPRR) Project

RERTR Meeting: Oct. 3-5, 2022

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PNNL-SA-178036

Critical Characteristics

- What they are,
  - Review previously shared information (2022 Stake Holders mtg)
  - Cover some examples and relevant ideas

- How to use them,
  - Review requirements and solution set structure
  - Status where we are and what the Team has accomplished
  - Look into some of these related details

- Why use them,
  - Review the capabilities and using a critical characteristics
  - Establish advantages and benefits
  - Communication paths and feedback loops

Standard vs Critical Characteristics (review)

The FF Pillar is tasked to help deliver capable fabrication processes and methods,

All drawing requirements & specifications must be satisfied

Standard Requirements:

End user perceives all parts equivalently w/in specification limits

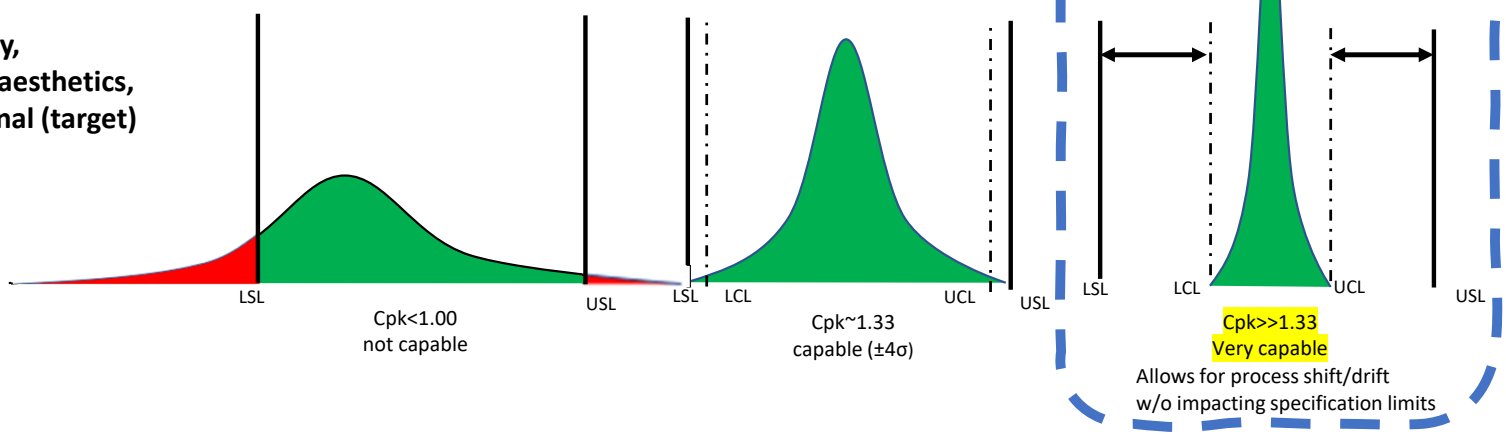
LSL/USL: lower & upper specification limits
LCL/UCL: lower & upper process control limits

(by using **LCL/UCL, Statistical Process Control limits** - the customer is protected from a non-compliance, these limits provide a buffer against variables present w/in the process)

Critical Requirements:

End user can perceive better safety, performance, function, durablity, aesthetics, when consistently closer to nominal (target)

Process Capability metric (Cpk) is needed for this



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Critical Characteristics (review)

Product designs can have **many** requirements & specifications

-For this portion of a side plate drawing,
count indicates there are 139 dimensional call outs for just this part of the drawing

79 require dimensional compliance, 19 of which are GD&T requirements

60 are (for reference only) – no compliance required

Important to Note -- this drawing has evolved this way over time

How would a maker know which requirements are important to Safety/Function/Performance/Durability?

-there is no way to tell, other than, 79 of 139 require compliance **and** this four decimal, B dim seems important, but its (ref.) also

If we were to use a CC approach

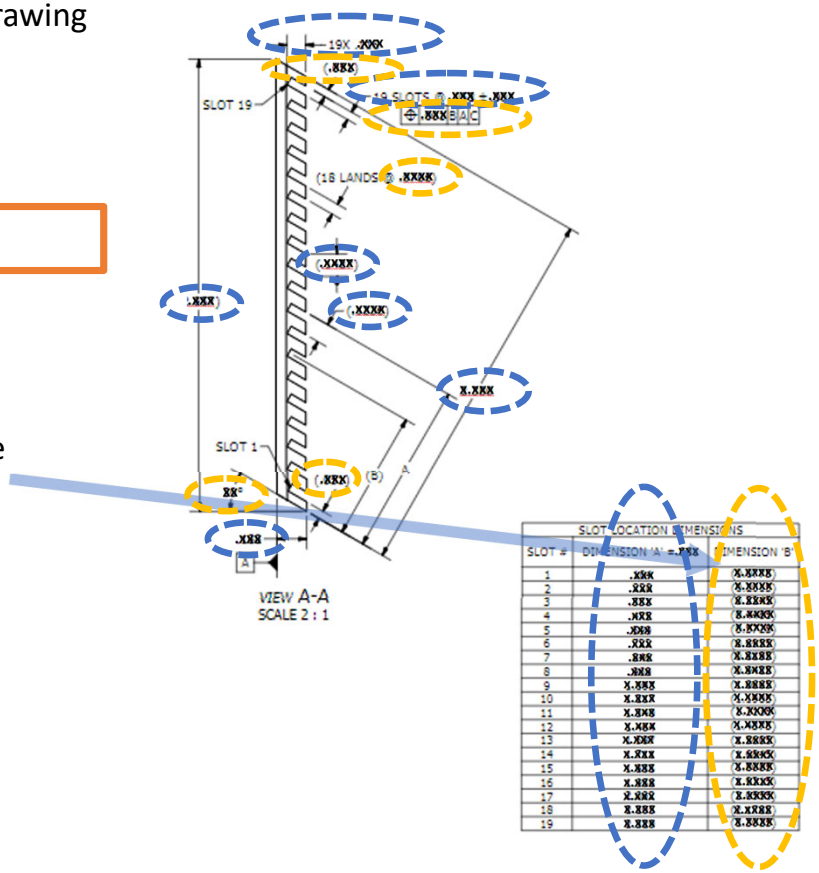
-most - Standard Characteristics (for example purposes only)

-some - Critical Characteristics (for example purposes only)

-merit increased significance in a Customer oriented perspective

-Safety/Function/Performance/Durability

SIDE PLATE DRAWING REQUIREMENTS



NRC Reactors and Critical Characteristics

Critical Fuel Product Characteristics

-Drs. Wilson & Stillman and the entire RC Pillar team

- **NUREG requirements**
- **USHPRR program: 18 requirements**
- **MITR Operational Requirements**
- **MURR Operational Requirements**
- **NBSR Operational Requirements**

NRC Reactor Critical Characteristics
(how this system works)

-USHPRR program
- -set of 18 requirements (RR-regulatory requirement)
  - -programmatic directives
- -NRC reactors
  - -set of 8 operational requirements/per reactor(AS-application solution)
    - -solutions for the RR
- -Fuel Designs (reactor specific)--*Product*
  - -NRC fuel has set of 30 requirements/per (DS-design solution)
    - -solutions for the AS
- -Fuel Fabrication--*Process and Production Systems*
  - -Fabricator has a set (>>30)/per (PS-process solution)
    - -solutions for the DS
      - -PS each have unique sets of Production Controls solutions

In a purist data sense:
18x(8x3)X(30x3)x(30x3)
~3.5M data pts that need some level of managing

Requirements Traceability

NRC Fuel Design Solutions
(product critical characteristics)

Design Solution/Critical Product Characteristic	
DS1	AA6061 Composition
DS2 (Reactor Specific)	Cladding Thickness (bulk minclad)
DS3 (Reactor Specific)	Cladding Thickness (point minclad)
DS4	Cladding-Cladding Bond Integrity
DS5	Fuel EBC and Impurities
DS6 (Reactor Specific)	Fuel Homogeneity
DS7 (Reactor Specific)	Fuel Homogeneity
DS8 (Reactor Specific)	Fuel Homogeneity
DS9	Fuel-Cladding Bond Integrity
DS10	Mo Content in U-10Mo
DS11 (Reactor Specific)	Plate Thickness
DS12 (Reactor Specific)	Plate U-235 Loading
DS13 (Reactor Specific)	Scratch depth
DS14	Uranium Enrichment
DS15	Zirconium Composition
DS16	Zirconium Thickness

16 Fuel Critical Characteristics

Design Solution/Critical Product Characteristic	
~~*DS17*~~	
DS18 (Reactor Specific)	Coolant Channel Thickness
DS19 (Reactor Specific)	Element U235 Loading
DS20 (Reactor Specific)	Nominal Fuel Element Geometry
DS21 (Reactor Specific)	External Fuel Element Cross-sectional Dimension
DS22 (Reactor Specific)	End Fitting Shoulder Fit
DS23 (Reactor Specific)	Fuel Element Fit
DS24 (Reactor Specific)	Outside Coolant Channel Thickness
DS25 (Reactor Specific)	Distance between upper end adapter window and lower end fitting shoulder
DS26 (Reactor Specific)	Inner Roller Position
DS27 (Reactor Specific)	Outer Roller Position
DS28 (Reactor Specific)	Length from center of end fitting to inside edge of end fitting tab
DS29 (Reactor Specific)	Width from center of end fitting to outer edge of end fitting
DS30 ((Reactor Specific)	Width from side plate to inside edge of end fitting tab

13 Element & Upper Level Assy CC

CC will help reduce LEU ICR/NCR

Utilize HEU fuel data as insight into eliminating these reactor and fabricator processing costs for LEU

ICR Data Assoc. w/XXXX 2013-2018					
Quantity of ICRs	Quantity associated w/ ICRs	Category	Qty: Rejected	Qty: Use as Is	Qty: On Hold (at date of data compilation (~2020))
7	46	end cap dimensionals	0	46	0
8	13	channel gap	1	11	1
1	9	testing error	0	9	0
1	1	data error	0	1	0
3	8	side plate groove	0	8	0
1	1	Fuel surface defects	1	0	0
2	2	min clad thickness	0	1	1
2	2	ID Location dimensional	0	2	0

ICR Data Assoc. w/ XXXX 2011-2021					
Quantity ICRs	Quantity associated w/ ICRs	Category	Qty: Rejected	Qty: Use as Is	Qty: On Hold
1	2	Contamination Fuel Issue	1	1	0
8	12	Damage/Defect Fuel	0	12	0
18	606	Process/Procedure Fuel Issue	3	603	0
3	6	Damage/Defect Element Assy	0	6	0
3	7	Dimensional Element Assy Issue	0	7	0
14	44	Process/Procedure Element Assy Issue	0	44	0
10	624	Dimensional Element Component Issue	0	624	0
1	100	Process/Procedure Element Component Issue	0	100	0

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This data appears to indicate that for this reactor, the assy and element components are more difficult for the manufacturer than the fuel

<u>What is allowing this many to occur??</u>

-why only 7/1,483 pcs rejected or on hold?

-what was learned and "fixed" from the 1,476 deemed "Use-As-Is"?

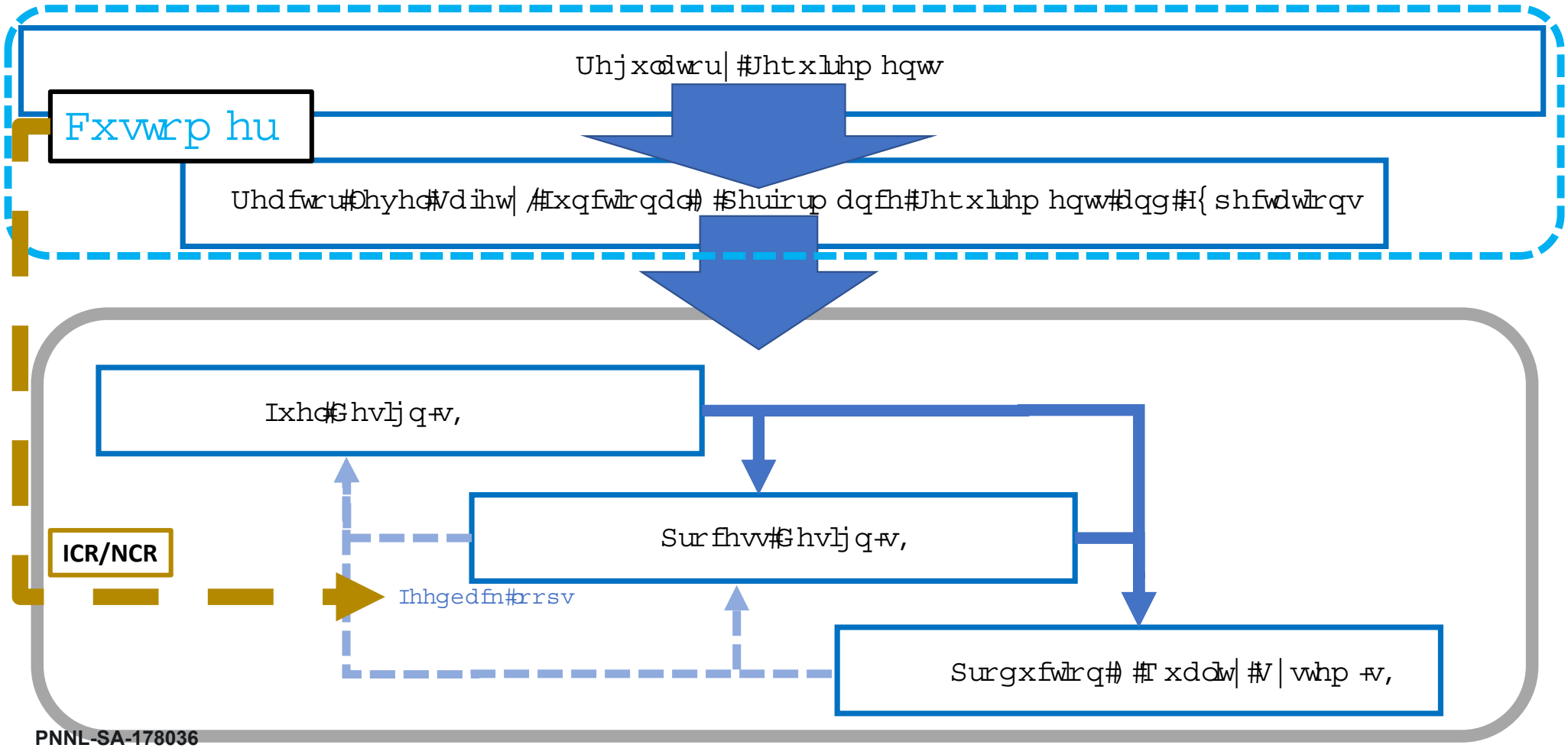
-which were critical to Safety/Function/Performance/Durability?

-Critical Characteristics can help with this!!

Similarly, this data appears to indicate that for this reactor, processing issues exist for both the fuel and element components

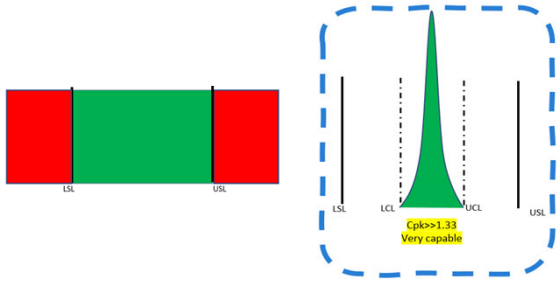
Critical Characteristics: Communication

Customer Focused Teams & Feedback Loops



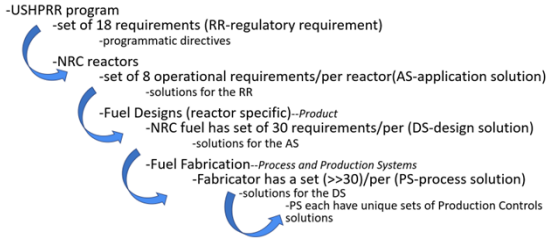
Critical Characteristics, Summary

- what they are,
  - standard vs critical



Enhance processing from just meeting specifications to customer focused, statistically capable processing where it matters the most

- how to use them,
  - establish requirement visibility
  - provide accountability using database insight and speed



- why use them,
  - enhance customer focus,
  - enhance end-product quality
  - improve manufacturability, efficiency, costs and through-put
  - reduce scrap, waste, ICRs/NCRs
  - **improve communication between customer, design, manufacturing teams**