



NRC Regulatory Guide 3.78

Acceptable ASME Section XI Inservice Inspection Code Cases for 10 CFR Part 72

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Topics



- Purpose and applicability of Regulatory Guide (RG) 3.78
- American Society of Mechanical Engineers (ASME) Code Case N-860
- Regulatory approach for ASME Code Case N-860 endorsement
- Public comments and revisions to RG 3.78
- Regulatory Analysis for RG 3.78
- Next steps
- Acknowledgements

Regulatory Guide 3.78



Purpose and Applicability

Identify acceptable ASME Boiler and Pressure Vessel Code (ASME Code), Section XI, “Inservice Inspection” Code Cases for use by ISFSI specific licensees, general licensees, and certificate of compliance (CoC) holders licensed under Title 10 of the Code of Federal Regulations (10 CFR) Part 72.

ASME Code Case Endorsement

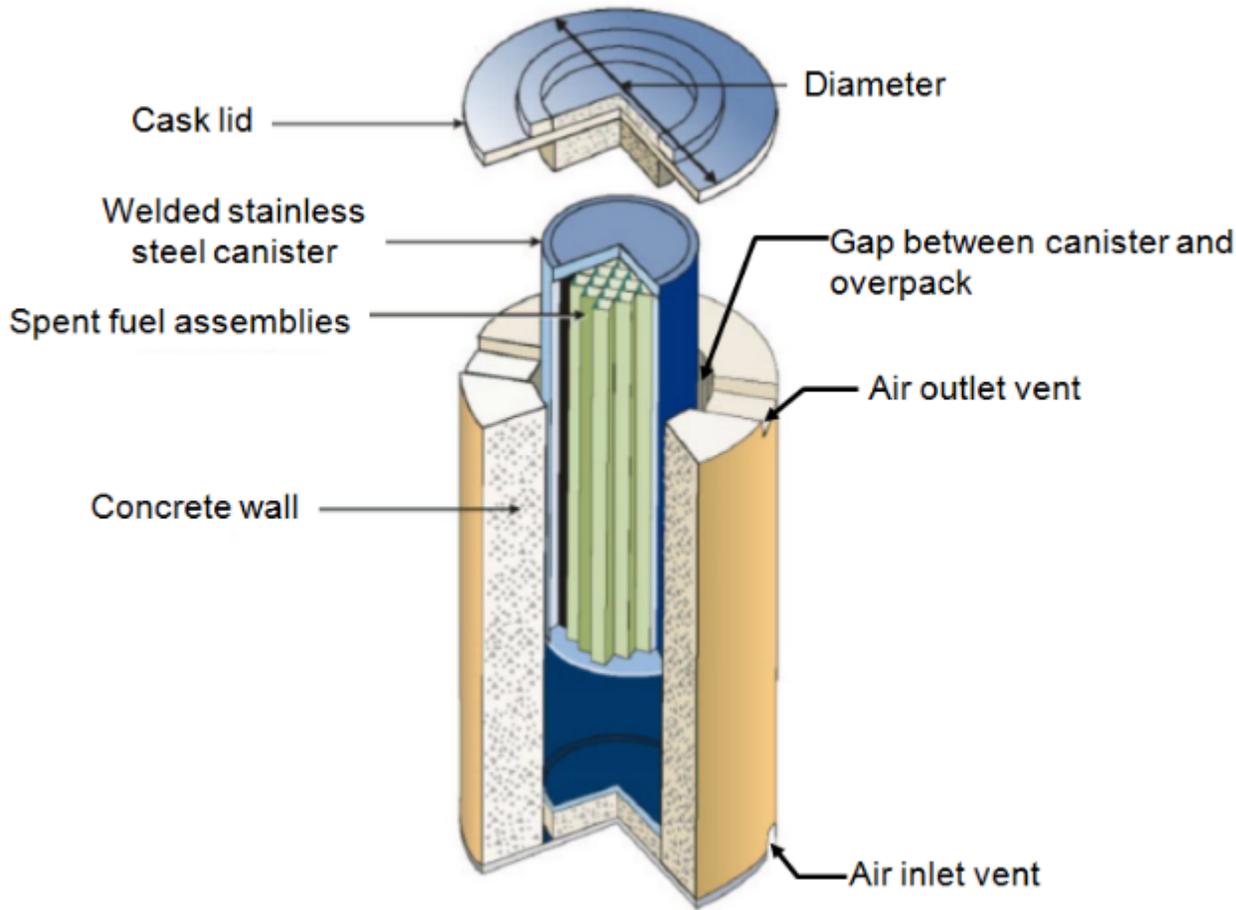
ASME Code Case N-860, “Inspection Requirements and Evaluation Standards for Spent Nuclear Fuel Storage and Transportation Containment Systems”



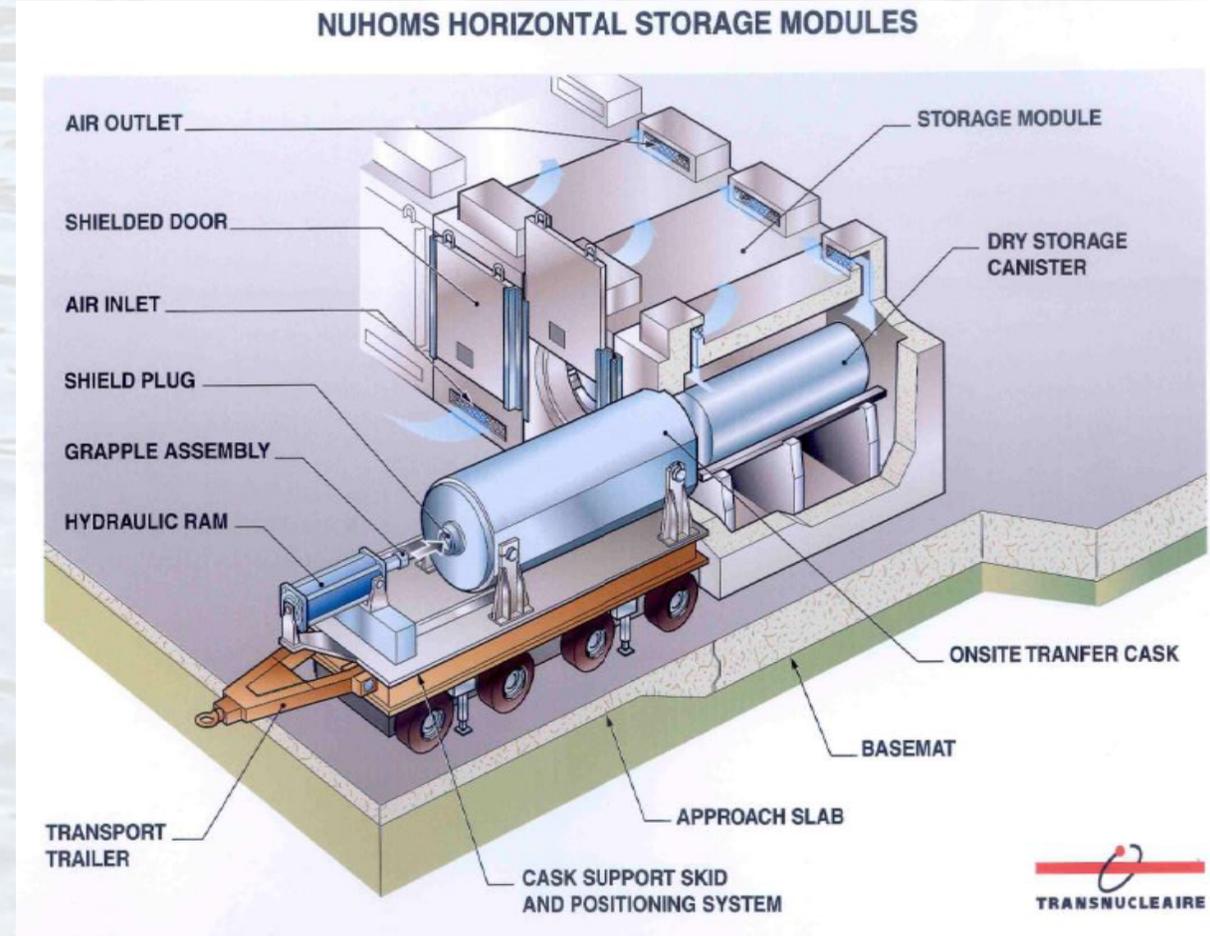
ASME Code Case N-860

- Developed over a 5-year period from 2015-2020 per NRC request (ML15083A020); ASME response (ML15224B452)
- Applies only to welded austenitic stainless steel canisters exposed to ambient air by passive ventilation
 - Majority (>90 percent) of dry storage systems in use
 - Currently used at 71 independent spent fuel storage installation (ISFSI) sites
- Assumes that chloride-induced stress corrosion cracking (CISCC) is the most credible and bounding degradation mechanism
 - Consistent with NUREG-2214, “Managing Aging Processes In Storage,”
 - Inspections of welded austenitic stainless steel canisters conducted to date have not identified instances of localized corrosion or CISCC

Canister Based Dry Storage Systems

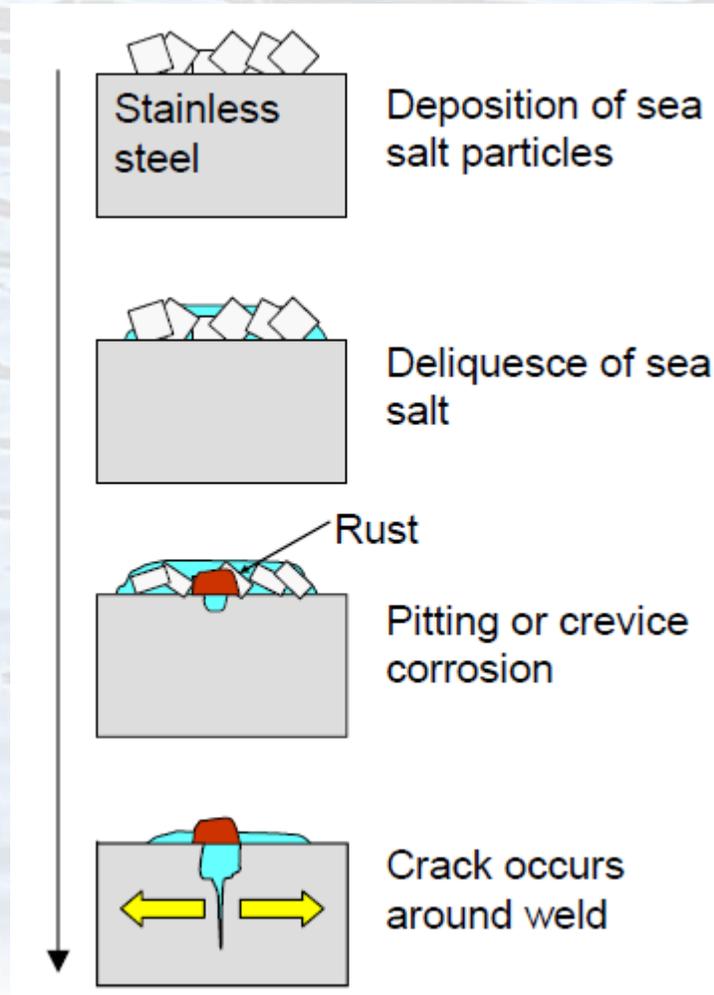


X. He et al., 2014, ML14323A067



B. Tripathi et al., 2015, SMiRT-23, Paper #185

CISCC of Power Reactor Components



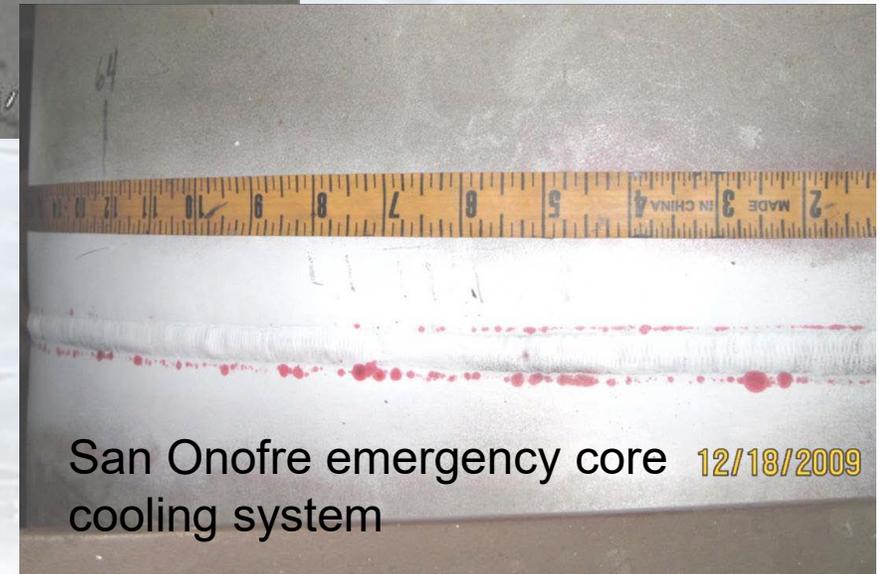
Shirai et al. 2011



Koeberg

Philip Doubell, 2010
Fontevraud 7 A108T03

Barry M. Gordon
2013 NACE International
Corrosion Conference
Paper No. 2539



San Onofre emergency core 12/18/2009
cooling system

ASME Code Case N-860



- Examinations on welded regions of canisters
 - Indications of localized corrosion (e.g., pitting corrosion) that can be a precursor to, or an initiation point for CISCC
- Progressive inspection methodology to identify and characterize corrosion
 - Visual screening examination
 - Visual assessment examination
 - Supplemental examination (surface or volumetric)
- Adjustment of number of canisters inspected and inspection frequency based on examination results



ASME Code Case N-860



- Uses EPRI–3002005371, Susceptibility Assessment Criteria for CISCC to set initial inspection population
 - CISCC ranking: $Z_{ISFSI} = Cl_{starting} + Cl_{adj} + AH_{adj}$
 - High rank site: $Z_{ISFSI} \geq 8$
 - Low rank site: $Z_{ISFSI} \leq 7$
- CISCC growth rate equation only considers canister surface temperature
 - Used to determine inspection interval if CISCC is identified (or likely)
 - Not intended to predict whether CISCC could occur
- Maximum inspection interval can be increased from 10 to 20 years for low rank sites ($Z_{ISFSI} \leq 7$) with no indications of CISCC



Regulatory Approach for N-860 Endorsement

- Methodology in ASME Code Case N-860
 - CISCC susceptibility assessment
 - Inspection intervals
- Additional technical information
 - Power reactor operational experience with CISC
 - ISFSI locations and inspection results
 - Composition of deposits on canister surfaces



Power Reactor CISCC Operating Experience

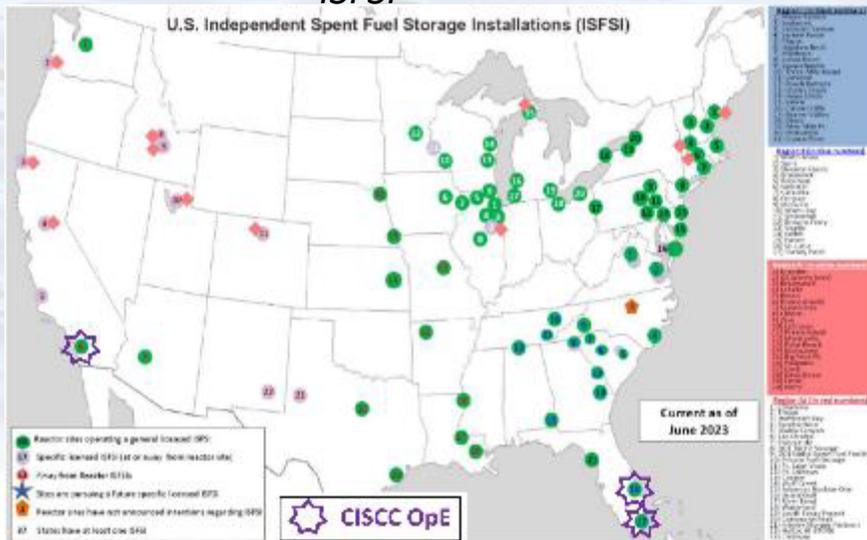
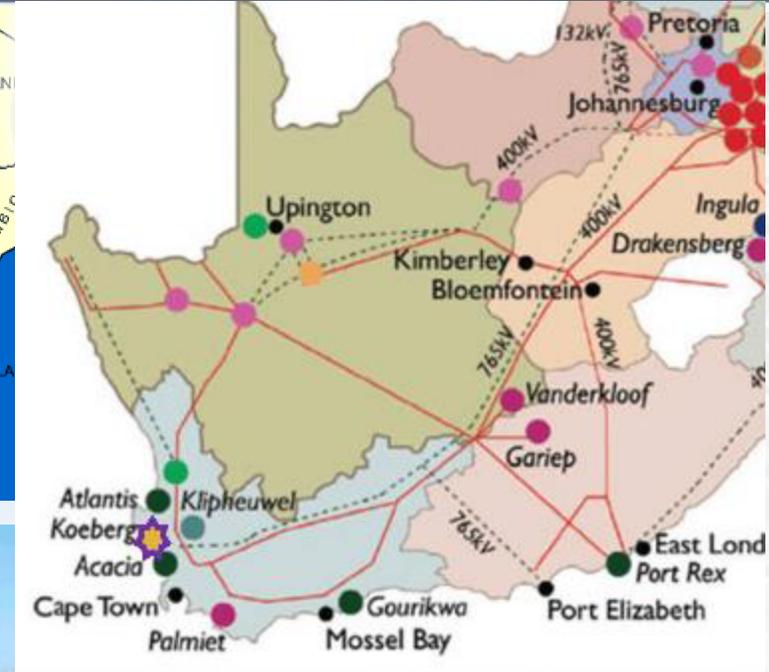
- NRC Information Notice 2012-20, “Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters,” 11/14/2012 (ML12319A400) - RG 3.78 Ref. 17
- CISCC of power reactor components, including stainless steel piping and tanks, has only occurred at locations near a marine shoreline
 - San Onofre Nuclear Generating Station (SONGS)
 - St. Lucie Nuclear Power Plant
 - Turkey Point Nuclear Generating Station
 - Koeberg Nuclear Power Station

ISFSI Inspection Results

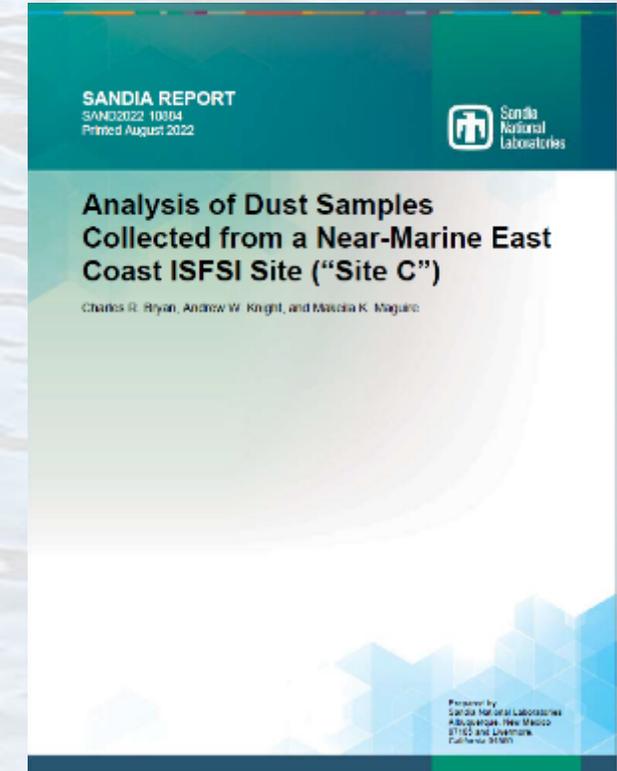
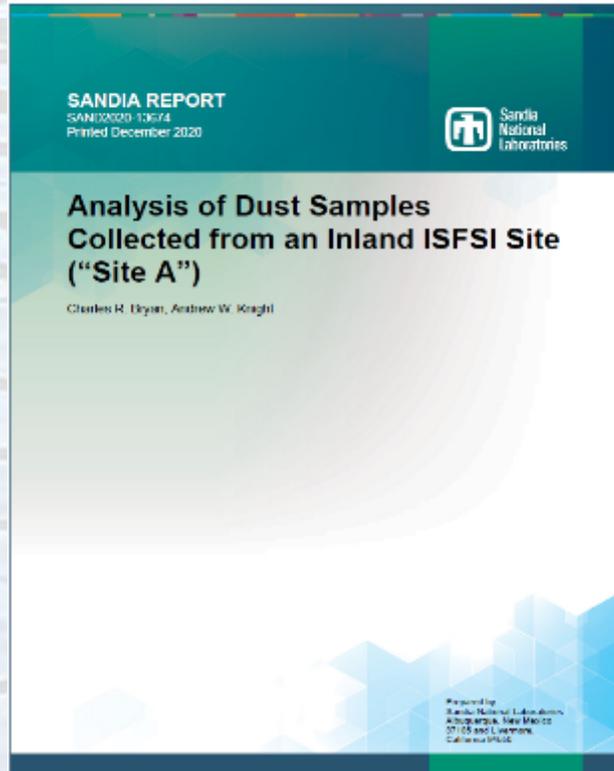


- No instances of localized corrosion or CISC on stainless steel canisters for ISFSI inspections conducted to date
- NRC Information Notice 2012-20, (ML12319A440) Atmospheric CISC of stainless steel, power reactor components has occurred at locations that are less than 1 km from a marine shoreline

$$Z_{ISFSI} \geq 7$$



Atmospheric Deposits on Canisters



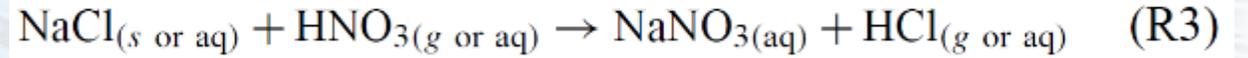
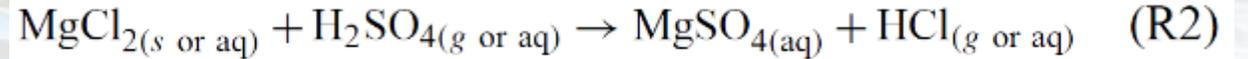
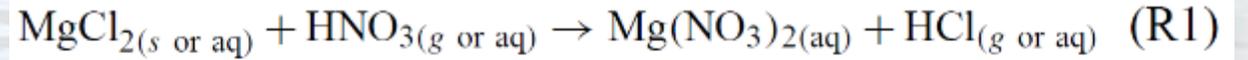
Risk of canister CISCC at these sites is low

RG 3.78 Ref. 14-16

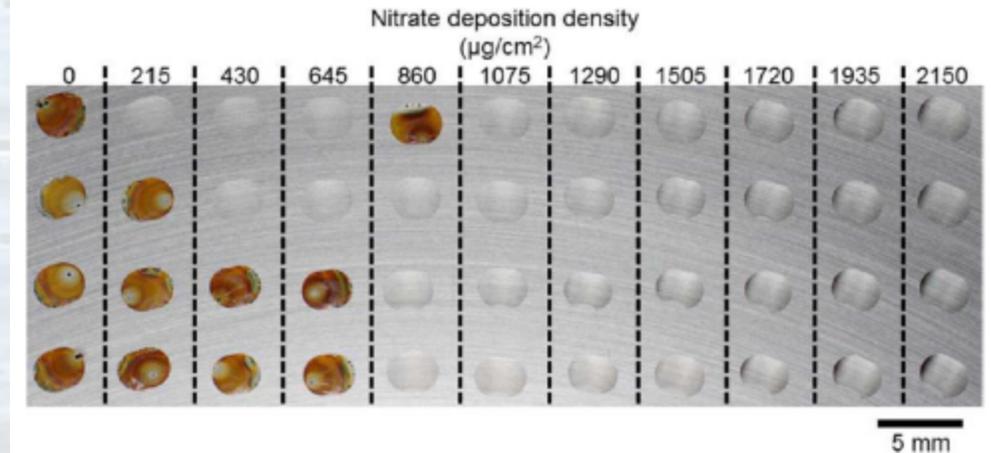
- Low, or very low, surface chloride concentrations
- Low chloride load, combined with relatively high concentrations of nitrate

Effects of Inhibiting Species

- Chi, et al. (2015) (Ref. 18) chemical transformation of sea salt aerosols chloride-rich => sulfate and nitrate
 - NO_x and SO_x emissions generated from combustion of hydrocarbon fuels (e.g., coal, diesel, and natural gas)
- Nitrate and sulfate are known to inhibit localized corrosion of stainless steels in chloride environments (Refs. 19–22)
- Nitrate is an effective inhibitor for CISCC of stainless steels (Refs. 23–25)



Chi, et al., 2015 RG 3.78 Ref. 18



Cook et al, 2017
RG 3.78 Ref. 22

Figure 7. 304L plate with 3.0 mm diameter droplets of MgCl₂ + Mg(NO₃)₂, exposed at 31°C and at 47% RH for 7 days. Image taken after exposure, before DI rinse. Constant chloride deposition density of 1230 µg/cm² for each droplet, nitrate deposition density varied as shown.



Staff Regulatory Guidance

- ASME Code Case N-860 is included in RG 3.78, Table 1, “Acceptable Section XI Code Cases for 10 CFR Part 72 Licensees and CoC holders.”
- Code Case N-860: maximum inspection interval can be increased from 10 to 20 years for low rank sites ($Z_{ISFSI} \leq 7$) with no indications of CISCC
- Alternate inspection interval allowed for inland ISFSI sites ($Z_{ISFSI} \leq 3$)
 - Allows inspection intervals of up to 40 years sites
 - Based on referenced technical information that was either not available or not considered during the development of ASME Code Case N-860
- Future acceptable ASME Section XI Code Cases applicable to 10 CFR Part 72 licensees and CoC holders



ISFSI Locations and Z_{ISFSI} Values

- 71 operating ISFSI sites with 3881 welded austenitic stainless steel dry storage system canisters in use as of October 2024
- The compositions of salt deposits on spent fuel storage canisters at ISFSI sites where $Z_{ISFSI} \leq 3$ are not expected to promote CISCC
- Assuming CISCC could occur, initiation time could be lengthy and the CISCC propagation rates would be much slower compared to rates that may be possible at marine sites

Z_{ISFSI}	Number of ISFSI sites (estimated)	Number of canisters (estimated)	Maximum inspection interval (yr)
1-3	60	3,259	40
4-7	6	307	20
8-10	5	315	10

Distance from ISFSI to Marine Shore	Starting Value ($C_{starting}$)
Less than 90 m	9
90 m to 1 km	8
1 km to 5 km	5
5 km to 20 km	2
More than 20 km	1

Public Comments



- Comments provided by the Nuclear Energy Institute (NEI)
 - Process for crediting previous inspections for N-860 to establish a 40-year inspection interval (instead of the 20-year interval allowed by N-860)
 - Consider going to a 40-year inspection interval for the following cases:
 - a licensee did not use Code Case N-860 when inspections were conducted
 - a licensee that follows an AMP that does not adopt the code case entirely (AMPs and code case adoption determined by the CoC holder)
- Additions to Regulatory Guide 3.78, Section C. Staff Regulatory Guidance
 - Licensees should follow ASME Code Case N-860
 - -2000 Inservice Inspection: how the inspection was conducted and the inspection results
 - -3000 Records and Reports: documentation of the inspection results and revisions to the inspection interval



Regulatory Analysis for RG 3.78

- Action Analysis: Issuing the RG recommended would result in costs and benefits shown in Table ES 1.

Table ES 1 Total Costs and Benefits for Alternative 2

Entity	Total (2024 dollars) ^a		
	Undiscounted	7% NPV	3% NPV
Industry	\$101,828,000	\$25,951,000	\$53,483,000
NRC	(\$718,000)	(\$588,000)	(\$656,000)
Net Benefit (Cost)	\$101,110,000	\$25,363,000	\$52,827,000

^a Values rounded to the nearest thousand dollars.

- Nonquantified Benefits: RG would provide improvements in knowledge and benefits to regulatory efficiency by standardizing several components of licensee ISFSI AMPs that choose to adopt the guidance
- Decision Rationale: NRC concludes that the RG is justified from a quantitative standpoint because
 - Benefits to licensees from the averted cost of ISFSI canister inspections outweigh the relatively minor cost to licensees and the NRC to issue and implement the RG
 - RG is also justified when considering nonquantified costs and benefits because the increase in regulatory efficiency

Timeline and Next Steps



Feb. 2024	<ul style="list-style-type: none">• Initiated development of Regulatory Guide (RG) 3.78
July 2024	<ul style="list-style-type: none">• Federal Register Notice: 89 FR 58080 issued• Draft Regulatory Guide 3.78 “Acceptable ASME Section XI Inservice Inspection Code Cases for 10 CFR Part 72,” (ML24093A010)• Regulatory Analysis for the Draft Regulatory Guide 3.78, June 2024 (ML24093A012)
Nov. 2024	<ul style="list-style-type: none">• Comment responses and revisions to RG 3.78
Dec. 2024	<ul style="list-style-type: none">• Advisory Committee for Reactor Safety (ACRS) Fuels, Materials, and Structures Subcommittee Meeting
Dec. 2024	<ul style="list-style-type: none">• Review by NRC Office of General Council (OGC)
Jan. 2025	<ul style="list-style-type: none">• RG 3.78 Final Publication (pending ACRS decision)
March 2025	<ul style="list-style-type: none">• ACRS Full Committee Meeting – Letter on RG 3.78 TBD

Acknowledgements



The contributions of the following staff are gratefully acknowledged

- Bruce Lin
- John Wise
- Carol Nove
- Stephen Cumblidge
- Ryan Meyer (ORNL)
- Harriet Karagiannis
- Bridget Curran
- Dan Ruby
- Tom Boyce
- Meraj Rahimi