

## SummerRAIsPEm Resource

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# Supplemental Requirement for Coupler Weld Acceptability (Vogtle LAR 15-010, WEC LAR-111)

# Agenda

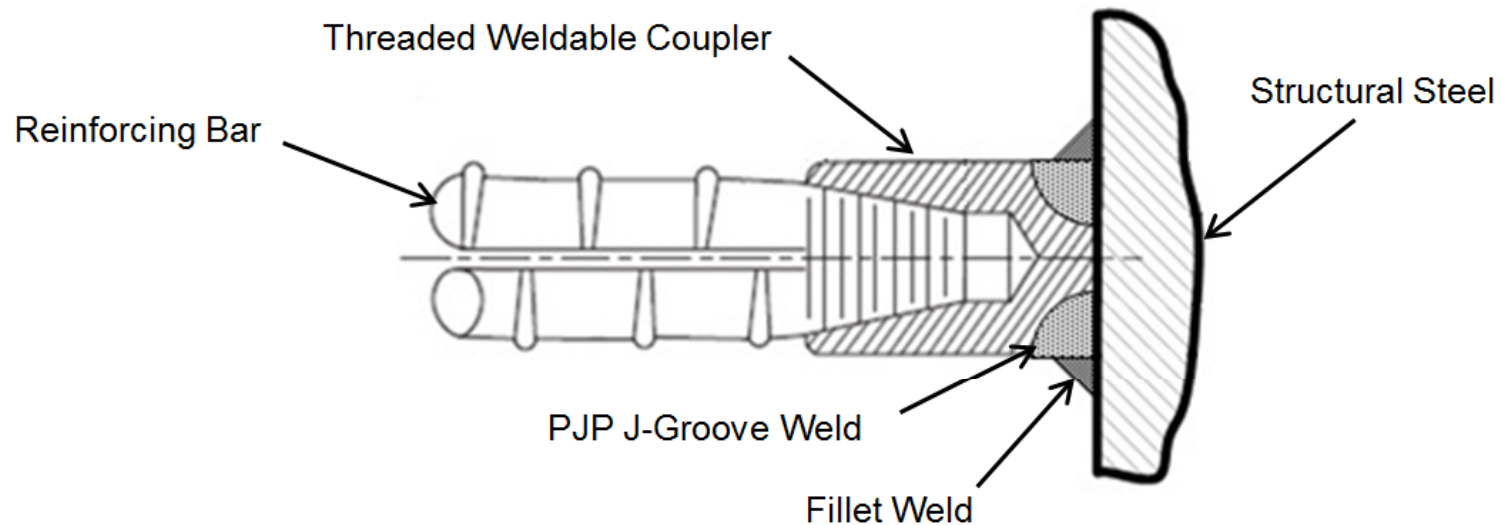
- Objectives
- Background
- Extent of Condition
- Problem Statement and Resolution Summary
- Safety Margin
- Scope of LAR-111
- Approach to Reconcile Past Work
- Approach for Future Work
  - Criteria Applied for Future Work

# Objectives

- Communicate Extent of Condition and Scope of LAR-111
- Communicate Licensee's View on Safety Significance
- Communicate Approach to Resolve Issue
  - As Found Condition
  - Future Work

# Background

- Weldable couplers are utilized in the AP1000 design where reinforcing bars are attached to structural steel.
- The couplers are attached to the structural steel using a combined partial joint penetration (PJP) weld with fillet weld reinforcement.



Lenton<sup>®</sup> C2/C3J Coupler

## Background

- The design function of the couplers is to mechanically anchor reinforcing bars to structural steel.
- As specified in UFSAR subsection 3.8.4.5, “Structural Criteria,” the analysis and design of concrete and structural steel conform to ACI 349-01 and AISC N690-1994, respectively.

# Extent of Condition Summary

## Extent of Condition: Where Directionality Used for Combined PJP + Fillet Weld

	Non-Coupler	C2/C3J Coupler	Position and Clevis Coupler
<b>Shield Building</b>	Condition Identified	Condition Identified	Condition Identified
<b>Other Structures</b>	None	Condition Identified	Condition Identified

- Shield Building Gusset welds will be resolved through analysis or rework in corrective action program (not included in LAR)
- Position and Clevis Coupler welds will be resolved through analysis in corrective action program (not included in LAR)
- C2/C3J Couplers discussed on next slide (LAR scope is limited to C2/C3J couplers)





## Problem Statement & Resolution Summary

- Design calculations invoked directionality for mixed welds that combine a partial joint penetration weld and a fillet weld
  - Scope limited to C2/C3J type couplers for #4 through #11 bars
- Calculations are being updated to qualify the welds reflecting the recent NRC feedback:
  - ACI 349 125% Yield strength of the bar as a design load
  - Calculations (hand calcs or FEA) using equations in AISC N690 (SLC of 1.6)
- Testing of all coupler sizes is being performed
  - Testing will be used to justify as-found welds that are non-compliant

**LAR scope will cover weld capacity demonstrated through testing.**

# Preliminary Assessment of Extent of Condition

Bar Size	Scope	Weld Capacity To be Demonstrated Through:
#4, 5, 6	All couplers	Calculation using a stress limit coefficient of 1.6
#8, 10, 11	All couplers	Analysis using Finite Element Analysis (FEA) per AISC N690-1994 Section Q1.22.2.1.2
#7, 9	Installed/Fabricated as found couplers	Testing per ACI 349-01 Section 12.14.3.4
#7, 9	Couplers not yet Fabricated	Increasing weld size through a design change. Analyze using a stress limit coefficient of 1.6

Note: Based on Preliminary Evaluation



**LAR scope will cover weld capacity demonstrated through testing.**

# Safety Margin

- As found condition and proposed change have adequate safety margin
- Intent of ACI 349 is met as the mechanical coupler system (including the weld) meets the 125% yield strength requirement and the weld is stronger than the rebar to ensure design is ductile
  - Weld is not the weak link in the design
  - Analysis and/or test results demonstrate that margin in the design is adequate to satisfy the yield strength requirements in the CLB



**A larger weld will not change the response of the structure in design basis or beyond design basis events**

## Proposed UFSAR Changes

- **3.8.4.5.1 Supplemental Requirements for Concrete Structures**

*[Weldable couplers attach reinforcing bars to structural steel using a combined partial joint penetration weld with fillet weld reinforcement. The coupler weld strength is evaluated in accordance with AISC N690-1994 and ACI 349-01 by demonstrating 125% yield strength of the reinforcing bar using a stress limit coefficient of 1.6. The fabricated welds that are unable to demonstrate this analyzed weld capacity and cannot be reworked are identified in the nonconformance process. The strength of these welds is demonstrated through testing per ACI 349-01 Section 12.14.3.4.1(a) and (b) by performing a minimum of six static and three cyclic qualification tests on samples of the coupler reinforcing bar splice and weld system.]\**

# Questions?

# Backup

# Approach to Reconcile Past Work (Coupler Bar Sizes #8, 10, 11) - FEA

- Linear elastic FEA performed
  - Coupler and weld detailed model
  - 125% of specified yield strength of reinforcing bar applied
- Confirm that weld stress from FEA is less than or equal to 1.6 times the working strength of the weld
  - $1.6(0.3)F_{EXX}A_w$
- Linearized stress path taken at effective throat as defined by AWS D1.1
- Preliminary results demonstrate #4, 5, 6, 8, 10, 11 couplers are within stress limits
- FEA geometry and loading being confirmed

**Weld Capacity demonstrated through FEA is in conformance with AISC N690-1994 Section Q1.22.2.1.2**



## Approach to Reconcile Past Work (Fabricated/ Installed Coupler Bar Sizes #7, 9) - Testing

- The consortium is performing tests of the mechanical coupler to demonstrate the coupler weld will meet the 125% requirement specified in ACI 349
  - Testing ongoing
  - Preliminary test results to date are indicating that coupler weld has margin to the 125% load requirement
  - In all cases the reinforcement bar (including threads) fails before the weld, thus ensuring a ductile failure mode of the connection
- Both AISC N690 and ACI 349 identify testing as a means to demonstrate the intent of the code in providing a ductile system

**Preliminary Test Results Show Margin to Design Limits and Demonstrate no Safety Issue**





## Approach for Future Work (Coupler Bar Sizes #7, 9)

- Increase weld size and demonstrate through analysis by comparing 125% of the specified design yield strength of the reinforcing bar using an SLC of 1.6.
- Future work is defined as those couplers not yet welded. Fabricated/installed welds will not be reworked.