

Section 6

ALLOWABLE FAILURE MODES OF FRANGIBLE STRUCTURES AND
THE NEED FOR ADDITIONAL IMPACT LOCATION EVALUATIONS

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TRIDYNAMIC SOLUTIONS

Under Consideration

- ▶ Previous stated: Failure mode shall be some form of windowing or segmenting.
- ▶ Impact points
- ▶ Define windowing
- ▶ Define allowable segment

Example: Impact Location Relative to Frangible Joints

- ▶ Simulation:
 - ▶ Composite Pipe (brittle failure)
 - ▶ 20 kg top mass
 - ▶ 6.0 m height
 - ▶ 1.0 from top impact
 - ▶ Equally spaced (42")
 - ▶ Joints shifted for impact point
 - ▶ On Joint
 - ▶ Offset near joint (6.5" below)
 - ▶ Between Joints

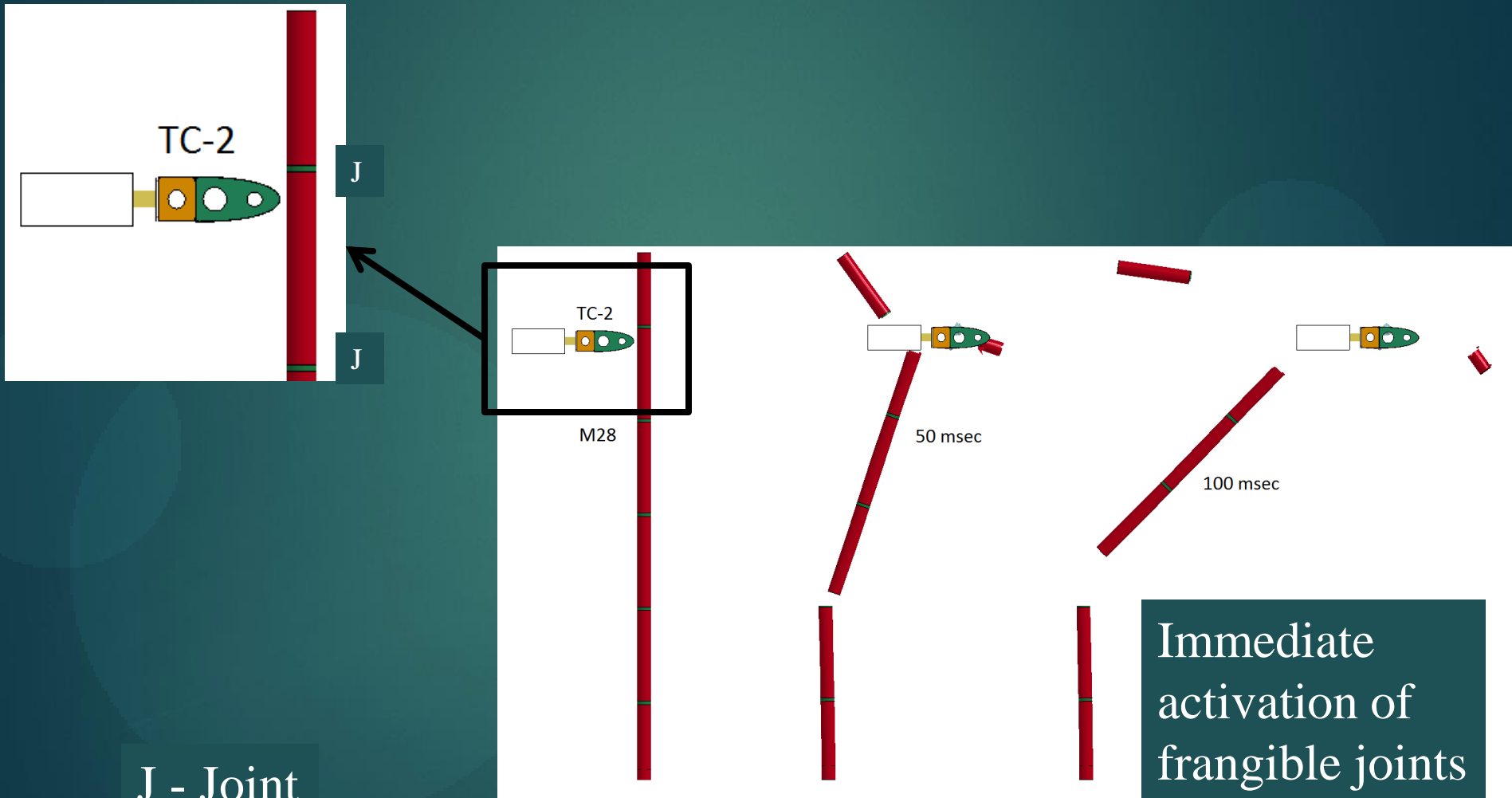
Impact Location Relative to Frangible Joints

Device Type	Model Number	Impact Position	Initial Peak Force (kN)	Force at Penetration to Main Spar (kN)	Maximum Energy (kN-m)
Composite Pipe	M71	On Joint	38.1		7.5
	M28	Offset Near Joint	38.0	43.9	10.4
	M72	Between Joints	38.1	46.7	11.7

56% Change in Energy



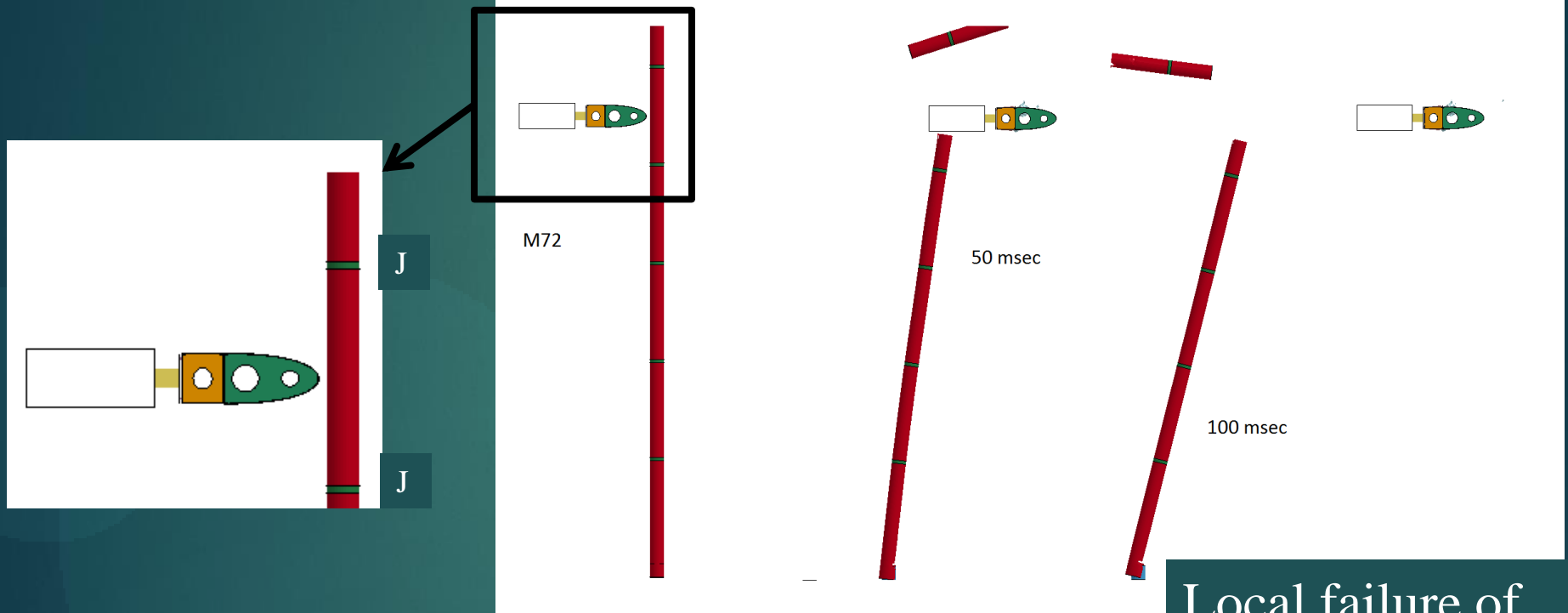
Difference in Response Near Joint



J - Joint

Immediate activation of frangible joints

Difference in Response Between Joints



J - Joint

Local failure of pipe with extended contact allowing global response.

Summary

- ▶ Impact location relative to frangible joints can have a significant influence on
 - ▶ Impact Energy
 - ▶ Tower Response

Under Consideration

- ▶ As stated previously, product failure mode shall be some form of windowing or segmenting.
 - ▶ The required failure mode shall apply to all potential impact locations.
- ▶ Given the windowing / segmentation requirement, use standard tower height of 6 meters.

Under Consideration

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- ▶ Impact heights (one impact point):
 - ▶ No less than 1 meter from the top of the tower.
 - ▶ No less than 50% of the tower height from the bottom of the tower.
 - ▶ No closer than $\frac{1}{2}$ meter to significant structural variations.
 - ▶ e.g. changes in cross section, cross arm brace connections, etc.
 - ▶ Does not include frangible joints.
- ▶ Require Impact point at the midpoint of the longest segment between frangible joints.
 - ▶ May require a second impact point.

Under Consideration

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- ▶ Windowing Defined:
 - ▶ The wing pass between major segments of tower above and below the impact point.
 - ▶ Small mass segments of structure may remain engaged with the impactor.
 - ▶ The segment shall be limited 4.0 kg max mass and 1.6 m max length??

Under Consideration

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- ▶ Failure mode shall be some form of windowing or segmenting.
- ▶ Impact points
- ▶ Define windowing
- ▶ Define allowable segment