



Pipes Vulnerability Under MMOD Hypervelocity Impact

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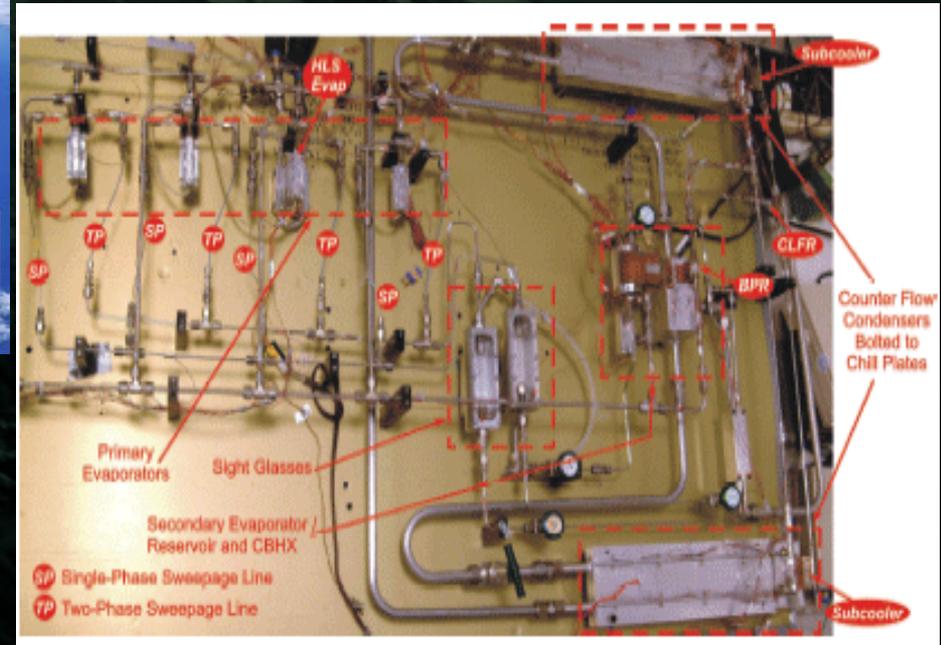
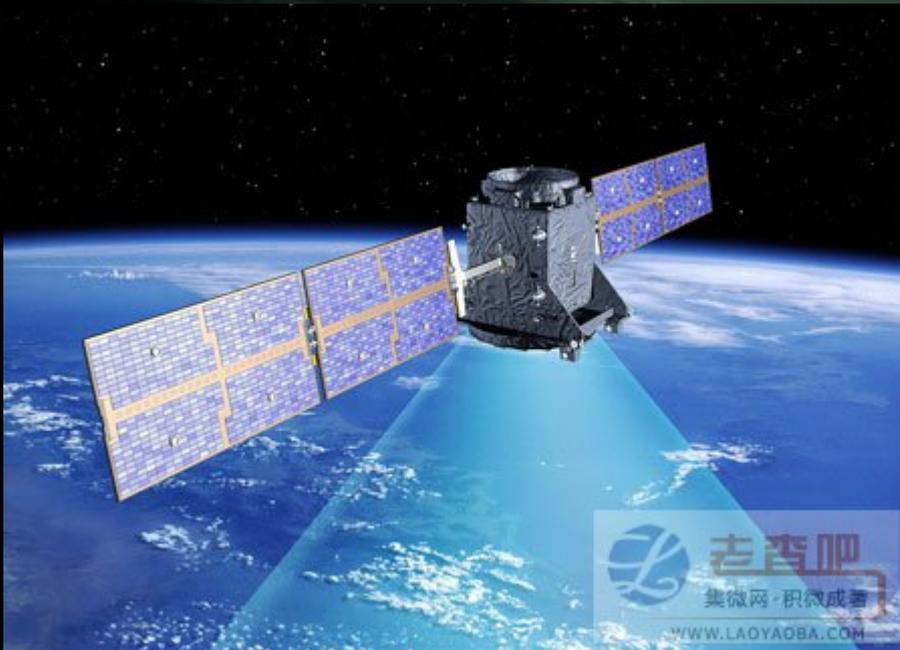
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1. Pipes System in Spacecrafts

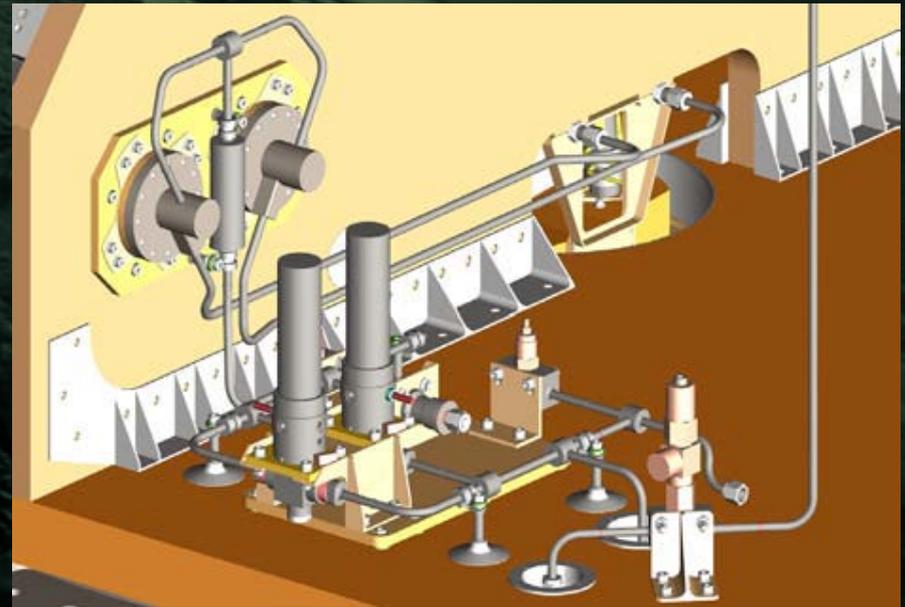
The pipes system is an important subsystem of the spacecraft, and its working status is closely related to the spacecraft mission.



Fuel Pipes

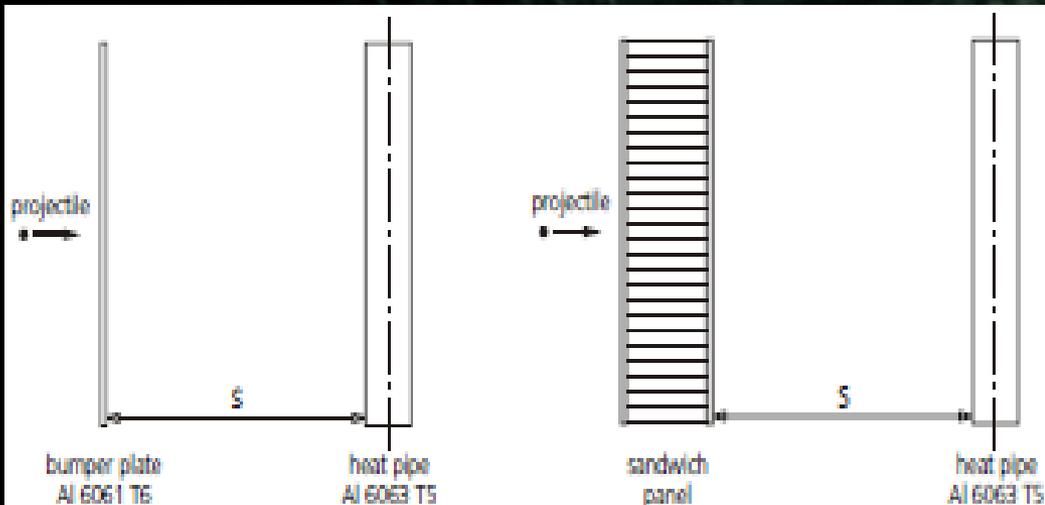
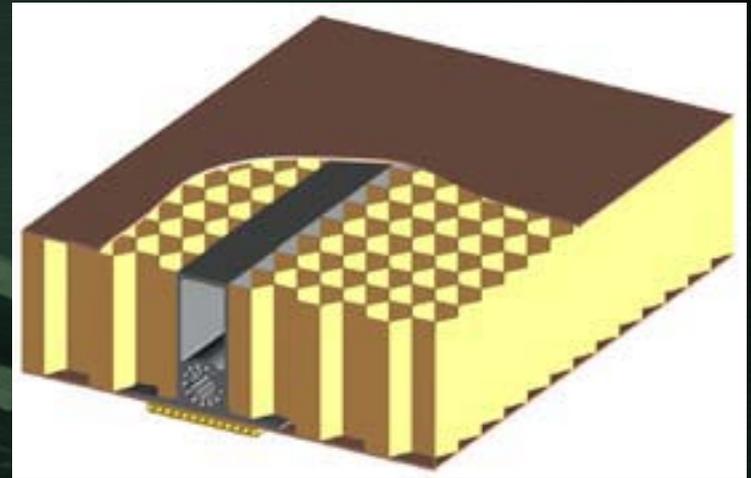
In many spacecraft applications feed lines, transporting propellant with a pressure in magnitude of 3Mpa can be found. These pressure lines are MMOD critical components due to their large amount of stored potential energy.

- a. cratering without leakage of fluid
- b. perforation leading to leakage of fluid
- c. catastrophic burst

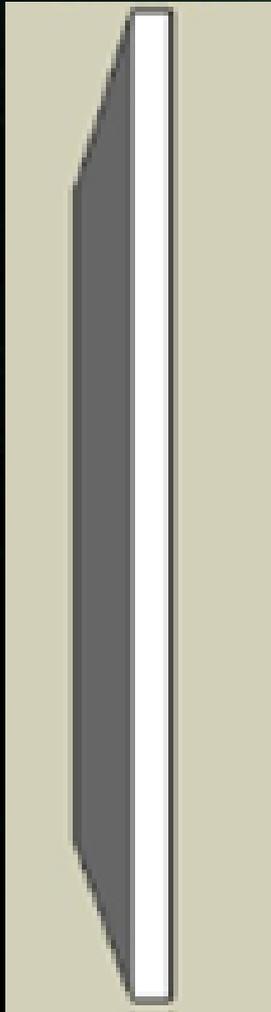


Heat Pipes

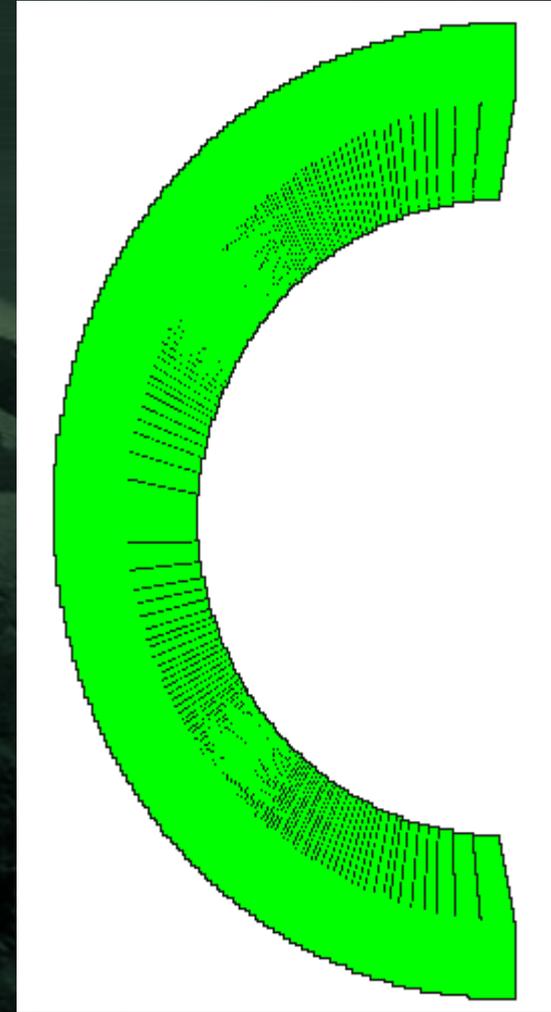
Heat Pipes contain high-pressure (up to 4.5Mpa) NH₃ and N₂.



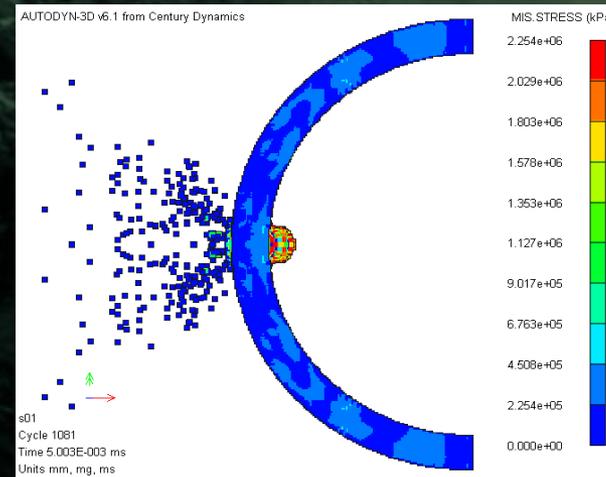
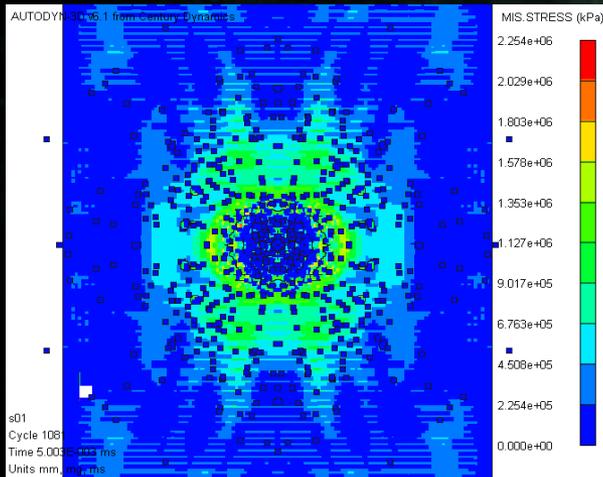
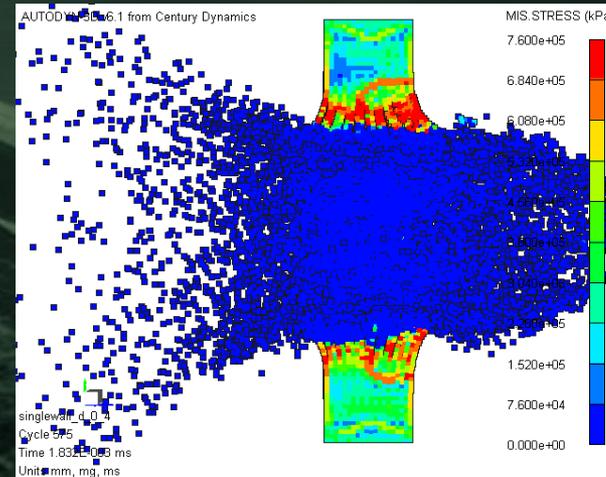
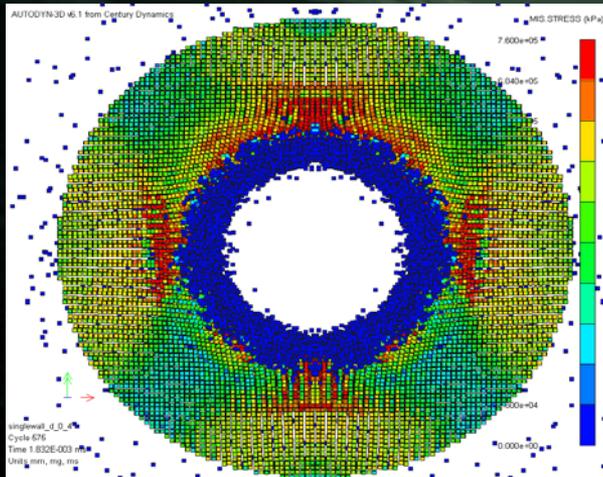
2. Vulnerability Differences between Pipes and Simple Homogenous Plates under HVI

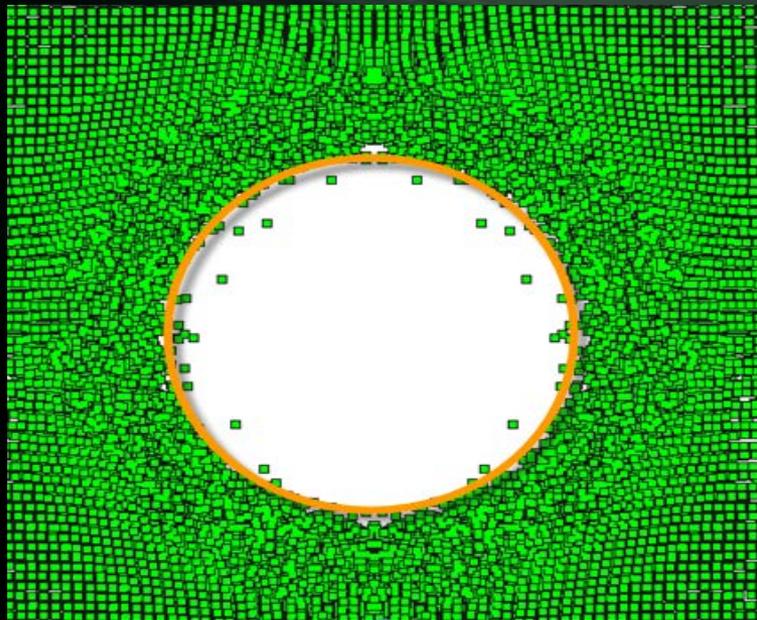


Curvature

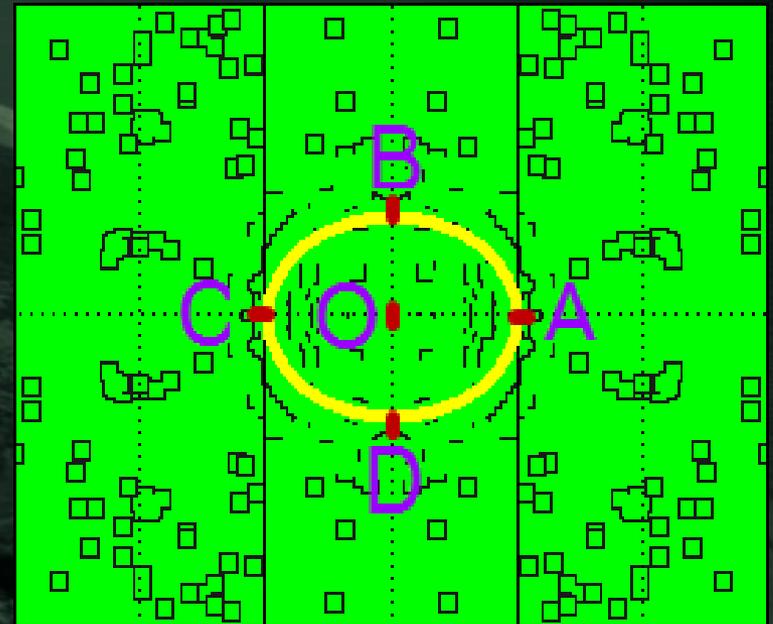


The SPH method is the best effective method to obtain the nature and rules in the hypervelocity impacting process





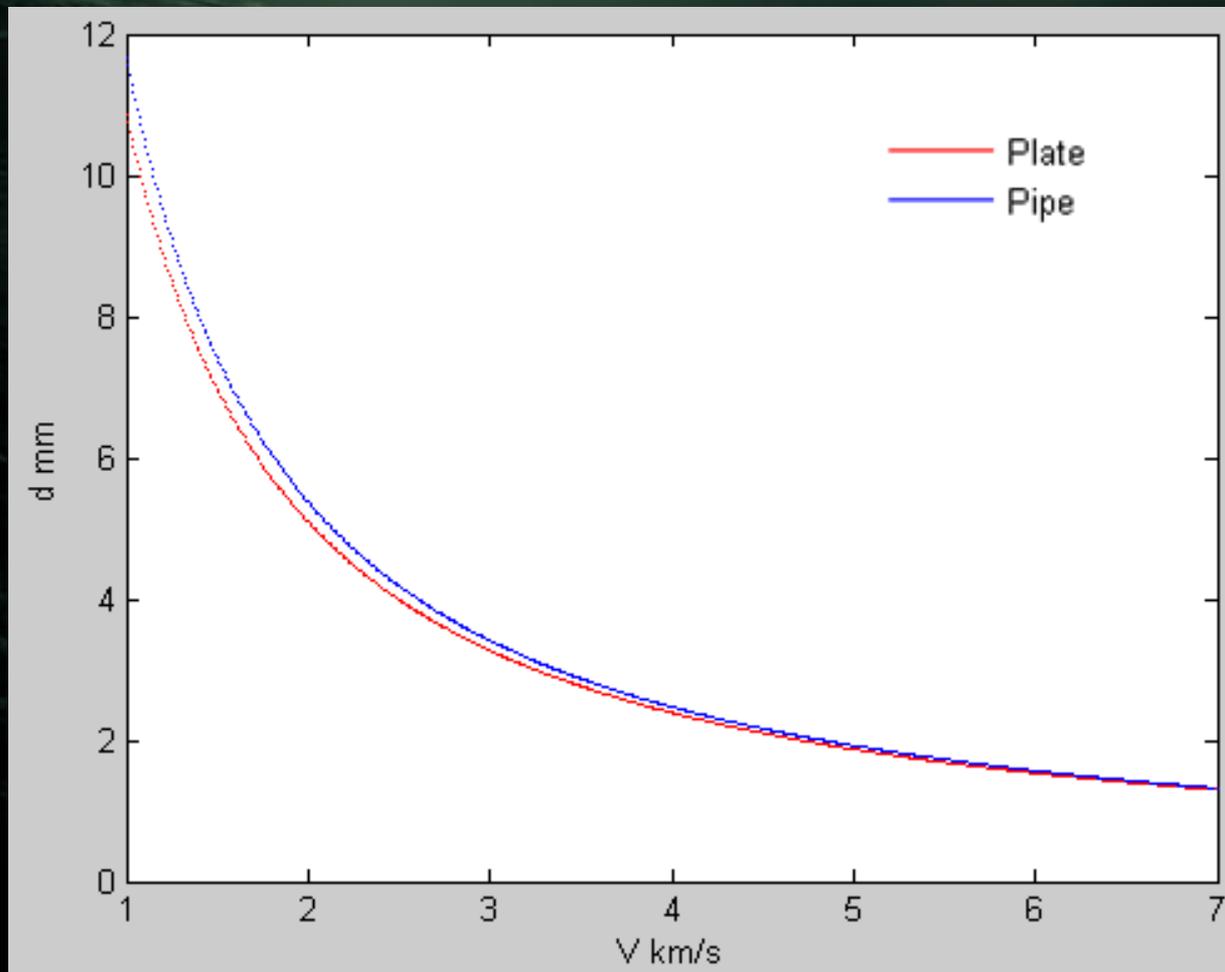
Crater Profile of Single Plate



Crater Profile of Pipe

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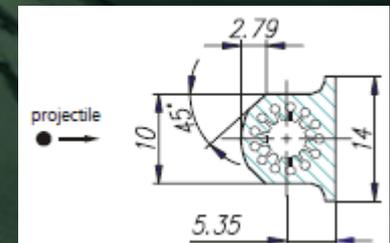
BLEs of Pipes and Plates under HVI



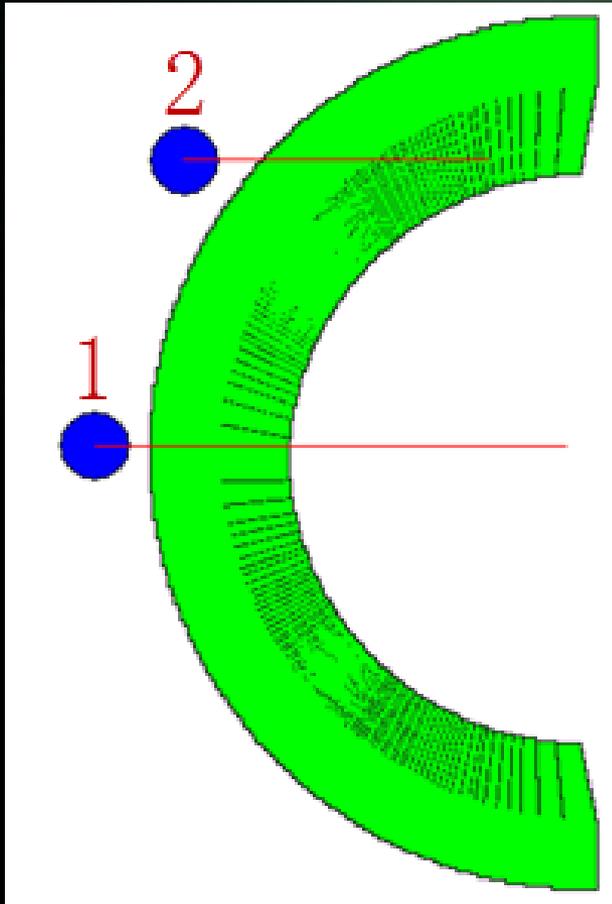
3. Off-centered Phenomena in Pipes Impact Experiments

Laboratory Experiments

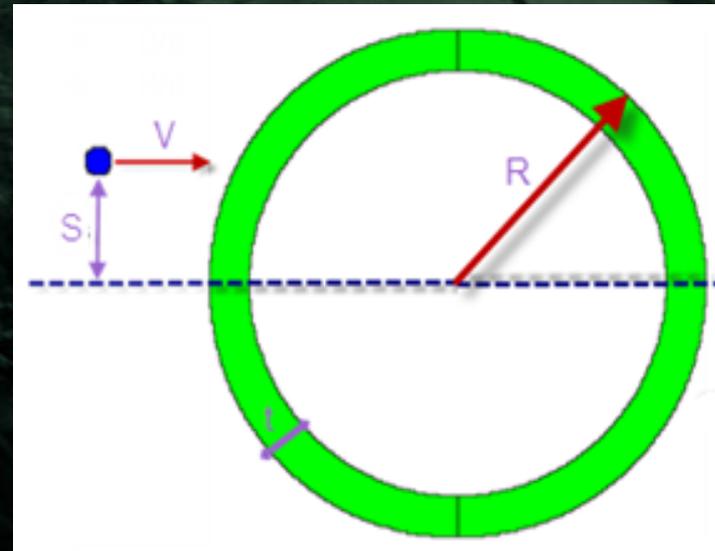
Laboratory experiments use light gas gun to launch hypervelocity projectiles onto the shield structures.



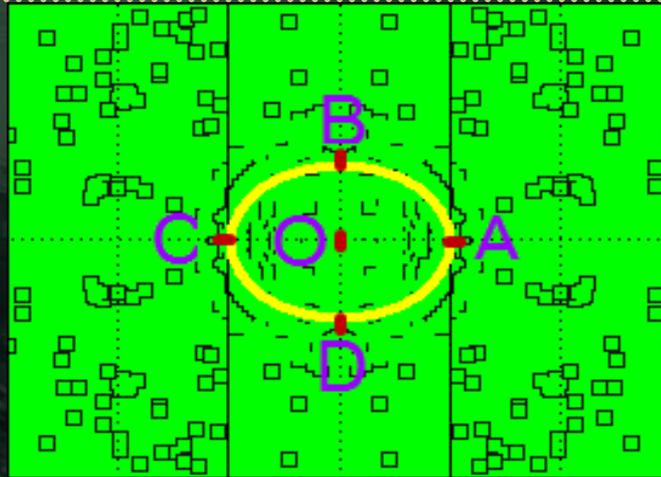
Light Gas Gun



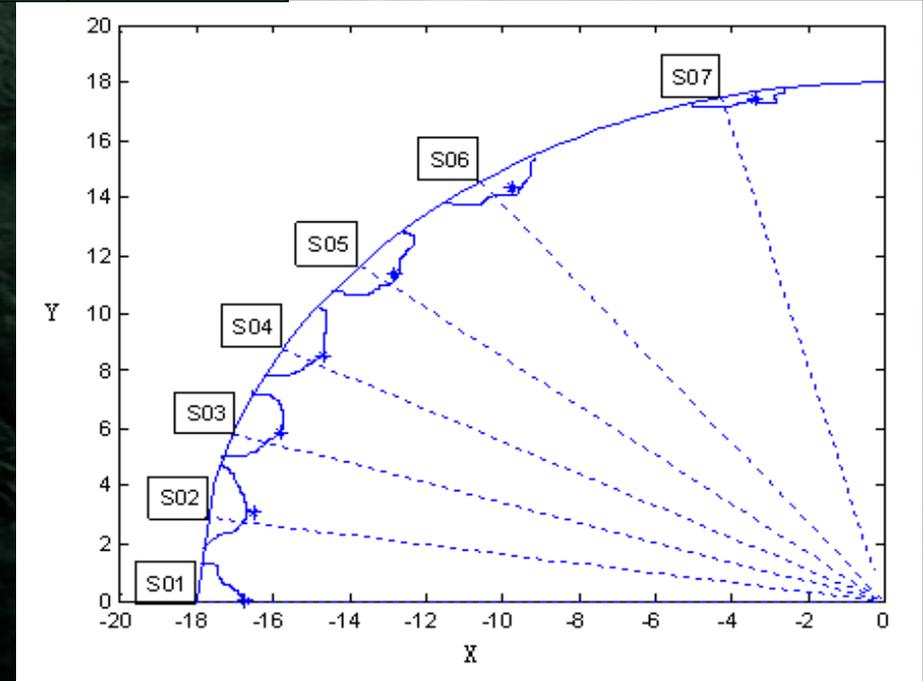
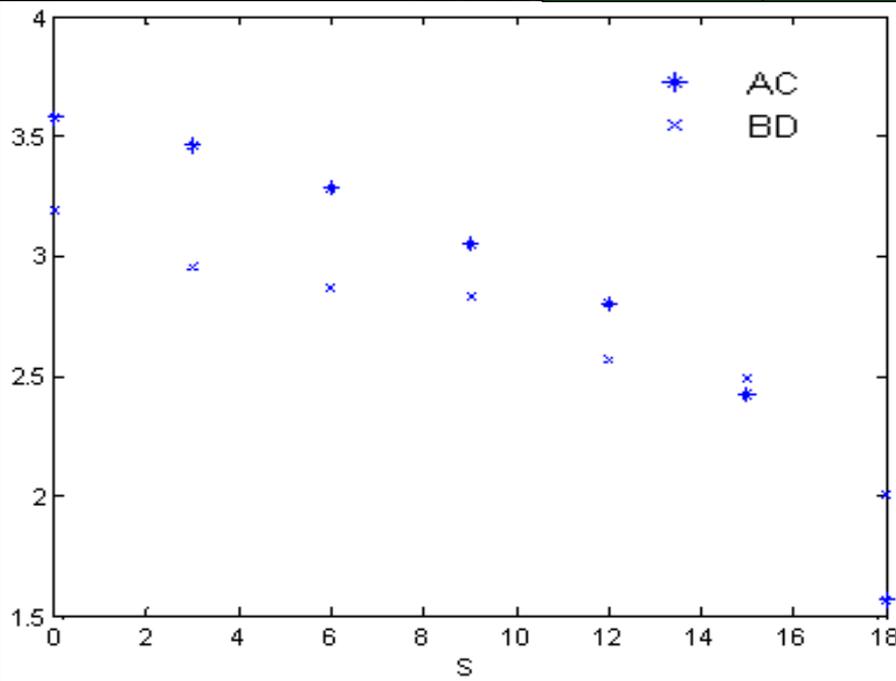
The anti-debris impact feature of situation 1 is equal to that of situation 2 ?



Damage Size of Crater Profile

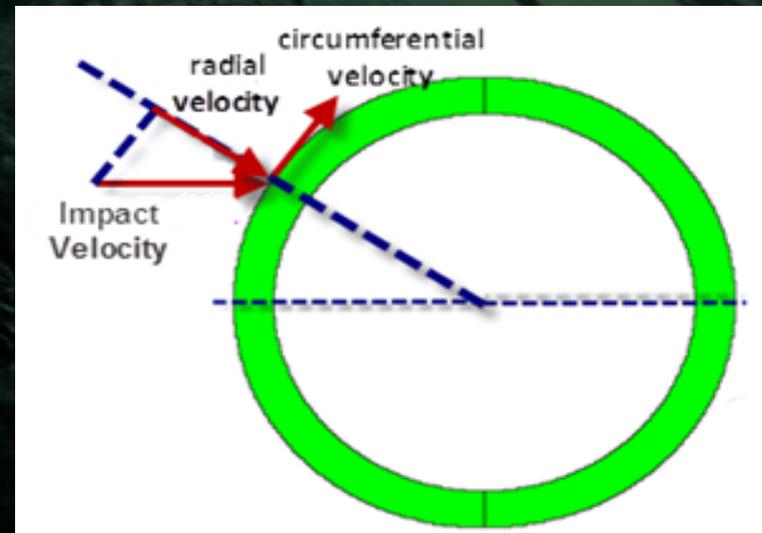


The Schematic Diagram of the pipe cross-section under HVI



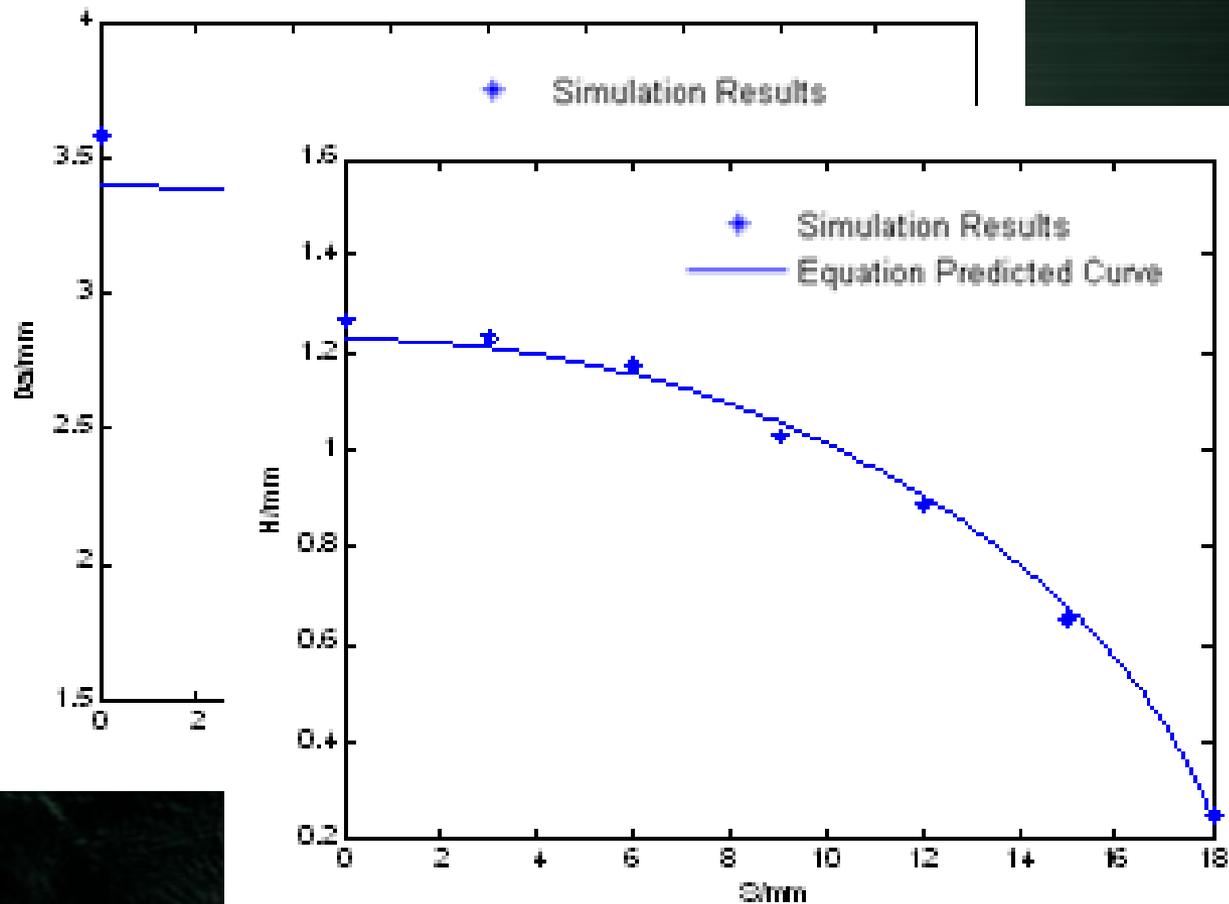
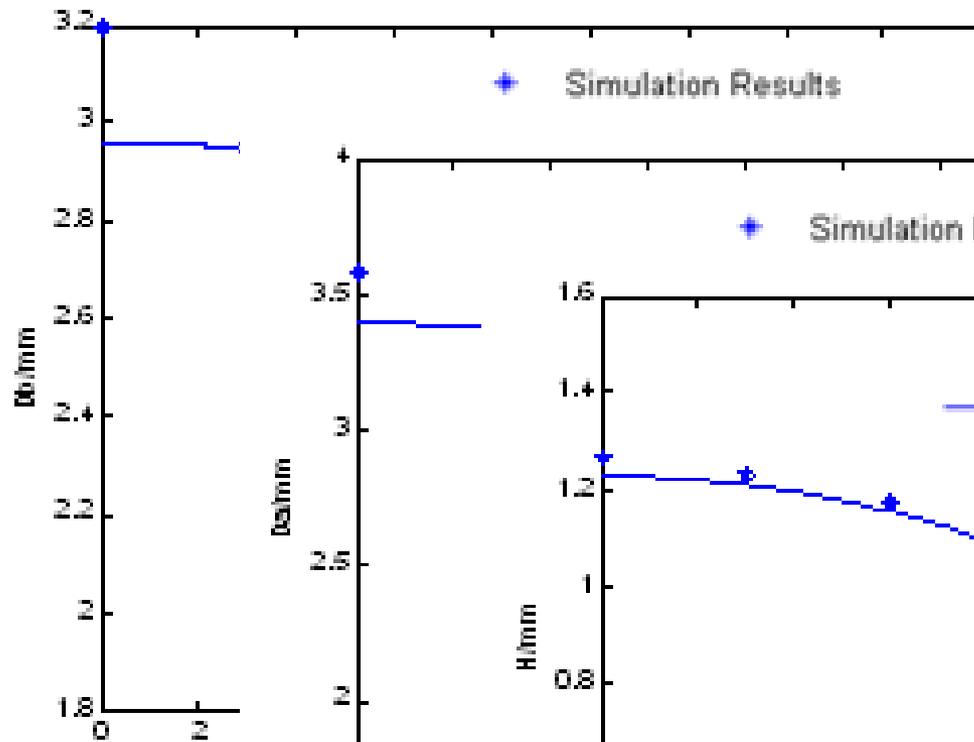
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- (1) The variation of the major axis is primarily and individually caused by the radial impact velocity.
 - (2) The variation of the minor axis is simultaneously caused by the radial impact velocity and the circumferential impact velocity.
 - (3) The crater depth is simultaneously affected by both the radial impact component velocity and the circumferential impact component velocity.

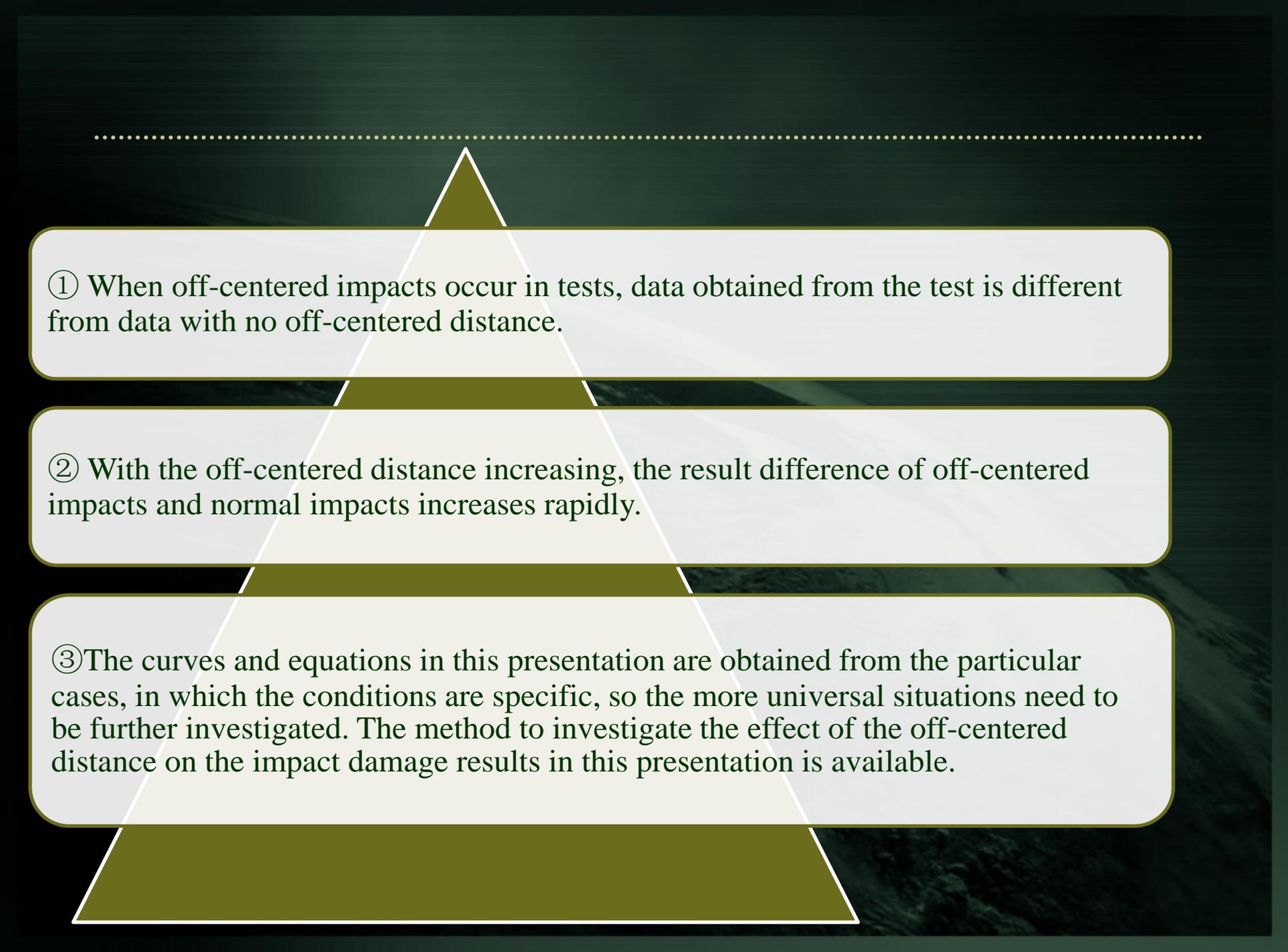
WHY?



Computer simulation results show:

The crater on the pipe is not an ellipse, when off-centered distance exists. It's a shape with unequal semi-minor axes in the circumferential direction and equal semi-major axes in the axial direction. The cause is that the off-centered distance leads to the change of the circumferential impact component velocity, the off-centered distance greater and the shape more unsymmetrical.





① When off-centered impacts occur in tests, data obtained from the test is different from data with no off-centered distance.

② With the off-centered distance increasing, the result difference of off-centered impacts and normal impacts increases rapidly.

③ The curves and equations in this presentation are obtained from the particular cases, in which the conditions are specific, so the more universal situations need to be further investigated. The method to investigate the effect of the off-centered distance on the impact damage results in this presentation is available.

4. Conclusions

(1) The anti-debris ability of pipes is better than Plates'

(2) The effect of the off-centered distance on the impact damage results shouldn't be neglected.



Thanks for Listening