

## Triggered Steam Explosions with Spontaneously Explosive Eutectic Corium in a Narrow 1-D Interaction Vessel in the TROI Facility

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### 1. Introduction

Although many studies have been performed worldwide on a steam explosion[1,2], there are only a few tests using real reactor materials. So the TROI steam explosion experiments have been carried out to evaluate the explosivity of corium. In the previous TROI tests, the effects of the water depth, corium composition and an external trigger were studied on the occurrence of a steam explosion in a 60cm wide interaction vessel (3-D geometry)[3,4,5,6]. It turned out that a shallow water pool, eutectic or pure material and the use of an external trigger easily led to steam explosions. However, the use of an external trigger did not cause a steam explosion in a 30cm wide interaction vessel (1-D geometry) with non-eutectic corium of which the composition was 80 : 20 at a weight percent of UO<sub>2</sub> : ZrO<sub>2</sub> [7]. In this paper, the results of two TROI tests(test No. 40 and 41) are presented using spontaneously explosive eutectic corium (70 : 30 at weight percent of UO<sub>2</sub> : ZrO<sub>2</sub>) in a 30cm wide interaction vessel by applying an external trigger.

### 2. Test Facilities

The test facilities of the TROI-40 and 41 tests are almost the same as the previous TROI-39 test[7]. Compared with the test, the initial ambient pressure was elevated to be 0.312MPa in the TROI-40 test to investigate the effect of an ambient pressure. In the TROI-41 test, the interaction vessel was raised by 50cm to reduce the melt freefall length. The aim of these tests is to observe triggered steam explosions using 70 : 30 eutectic corium in a 30cm wide interaction vessel by applying an external trigger. An explosive (PETN 1g) was used as the external trigger.

### 3. Test Results

The TROI-40 and TROI-41 tests have been performed by applying an external trigger with 70 : 30 eutectic corium which was spontaneously explosive in a 60cm wide vessel. The initial conditions and test results are presented in Table 1. In both cases, no triggered steam explosions occurred. The dynamic pressure and load for both tests in Table 1 are caused by an external trigger.

#### 3.1 TROI-40 Test

In the TROI-40 test, 18.000kg of 70 : 30 corium (UO<sub>2</sub> : ZrO<sub>2</sub>) was charged into the crucible and melted. Then 11.095kg of the molten corium at 3000K was delivered into a 130cm deep and 30cm wide water pool at 0.312MPa. The external trigger was set to explode at 1.40 seconds but exploded at 1.385 seconds due to the error bound of the trigger timer unit. Previously, the corium of this composition led to a spontaneous or triggered steam explosion in a 60cm wide interaction vessel in the previous tests[4,5]. However, no triggered steam explosion occurred in this test. This can be deduced from the comparison of the dynamic pressure signals in this test as shown in Figure 1 with those in the explosive calibration test as shown in Figure 2. The calibration test was performed without a melt delivery so the dynamic pressure was caused only by an external trigger(explosive). The signals from TROI-40 are very similar to those of the calibration test except for the duration, especially from the aspect of no peaks by a triggered steam explosion.

Table 1. Initial conditions and test results

	TROI test number	Unit	40	41
Melt	Initial Composition	[w/o]	69/30/1	69/30/1
	UO <sub>2</sub> / ZrO <sub>2</sub> / Zr			
	Temperature	[K]	3000	3500
	Charged mass	[kg]	18.000	18.000
	Released mass	[kg]	11.095	1.470
	Initial jet diameter	[cm]	8.0	8.0
	Free fall in gas	[m]	3.1	2.6
Test Section	Water mass	[kg]	92	92
	Initial height	[cm]	130	130
	Final height	[cm]	88	85
	Initial temperature	[K]	287	291
	Sub-cooling	[K]	121	82
Pressure Vessel	Initial pressure(air)	[MPa]	0.312	0.110
	Initial temperature	[K]	286	295
	Free volume	[m <sup>3</sup> ]	8.023	8.023
Results	Maximum PV pressurization	[MPa]	0.052	0.071
	Maximum PV heat-up	[K]	50	80
	Maximum water heat-up	[K]	56	9
	Steam explosion		NO	NO
	Dynamic pressure peak (by the External Trigger)	[MPa]	12.7	14.5
	Duration (by ET)	msec	1.6	0.6
	Impulse (by ET)	kN	280	200
	Duration (by ET)	msec	8	11

### 3.2 TROI-41 Test

In the TROI-41 test, 1.470kg of the molten eutectic corium at 3500K was delivered into a 130cm deep and 30cm wide water pool. The external trigger was exploded by the time of the melt-bottom contact (~1.43 seconds after the melt delivery). However, no triggered steam explosion occurred. This fact is deduced from the dynamic pressures shown in Figure 2 and Figure 3. The signals from TROI-41 are almost the same as those of the calibration test. This means that the pressure signal was produced by only an external trigger.

### 4. Conclusion

Two steam explosion experiments in a 30cm wide 1-D interaction vessel have been performed using explosive eutectic corium by applying an external trigger. In both cases, no steam explosions occurred. The reason is thought to be that the relatively high void fraction in the narrow 1-D interaction vessel prevented steam explosion propagations to the nearby water due to a water depletion. More steam explosion experiments need to be carried out to measure the void fraction just before the triggering, which affects the occurrence of a steam explosion.

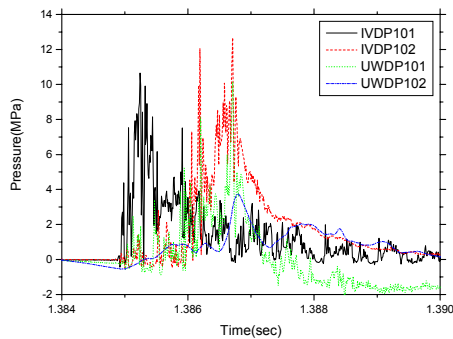


Figure 1. Dynamic pressures in the TROI-40 test

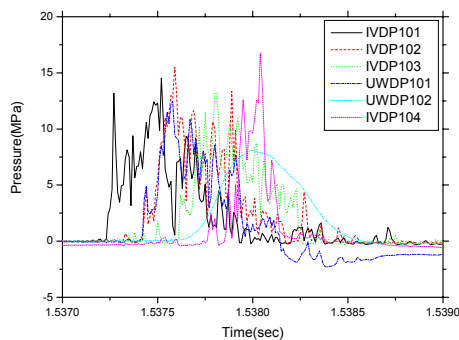


Figure 2. Dynamic pressures in the explosive calibration test

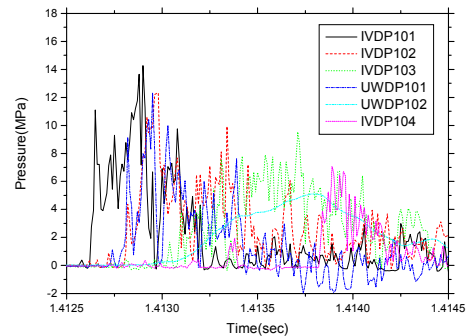


Figure 3. Dynamic pressures in the TROI-41 test

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