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ZION/INDIAN POINT

TECHNICAL EXCHANGE MEETING

CHICAGO, ILLINOIS

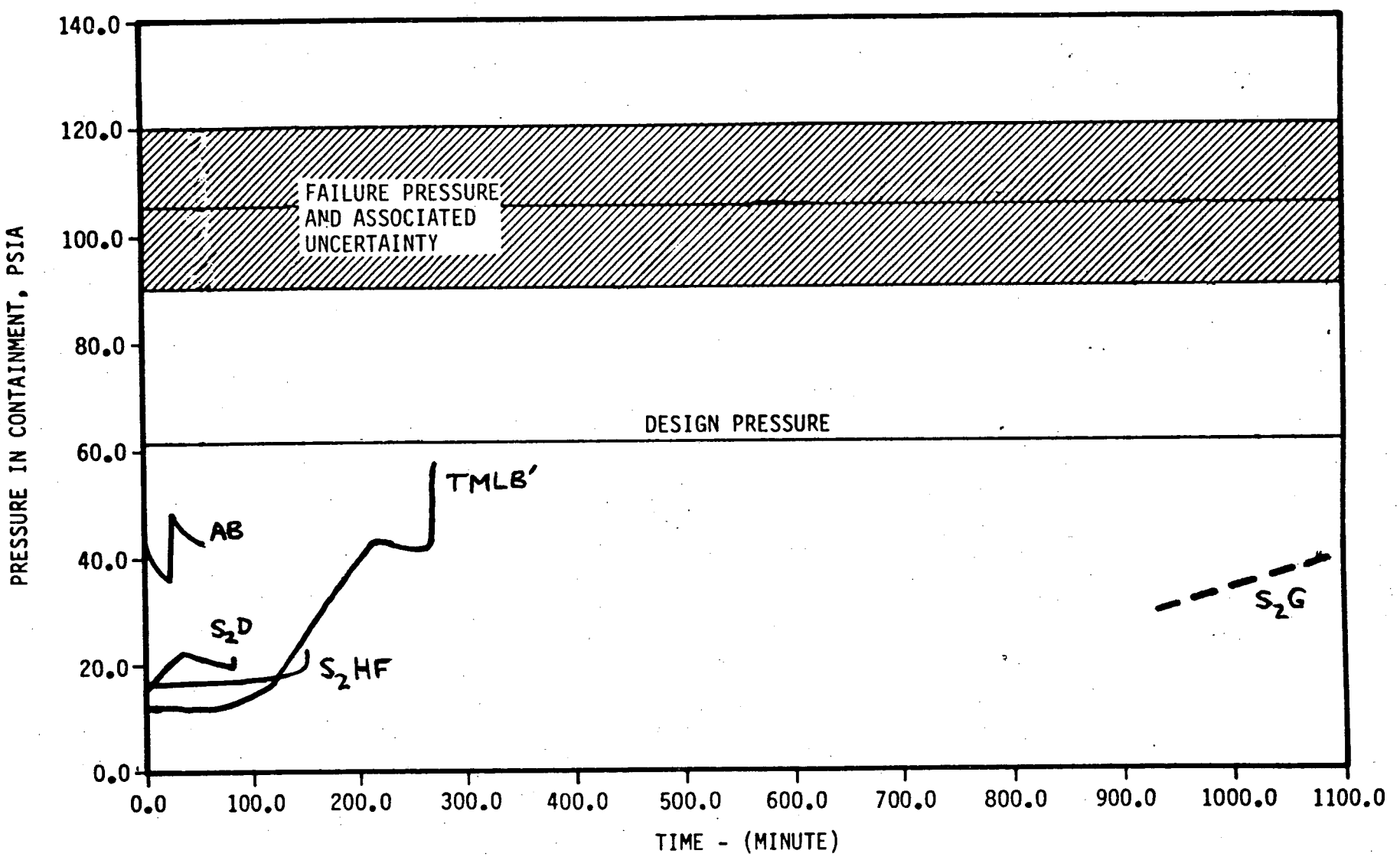
MAY 7-8, 1980

ALLAN S. BENJAMIN

SANDIA NATIONAL LABORATORIES

65

CONTAINMENT PRESSURE VERSUS TIME PRIOR TO REACTOR VESSEL FAILURE



IMPLICATIONS OF POWER RESTORATION

- ECCS DELIVERY WHEN CORE IS INTACT OR ONLY PARTIALLY MOLTEN MIGHT CAUSE COARSE FUEL FRAGMENTATION
- ECCS DELIVERY AFTER MOST OF CORE IS MOLTEN COULD CAUSE FINE FRAGMENTATION OF FUEL AND RAPID STEAM GENERATION
  - CONTAINMENT PRESSURIZATION
- AUXILIARY FEEDWATER DELIVERY AFTER STEAM GENERATOR DRYOUT COULD CAUSE STEAM GENERATOR TUBE RUPTURE LEADING TO RELEASES OUTSIDE CONTAINMENT

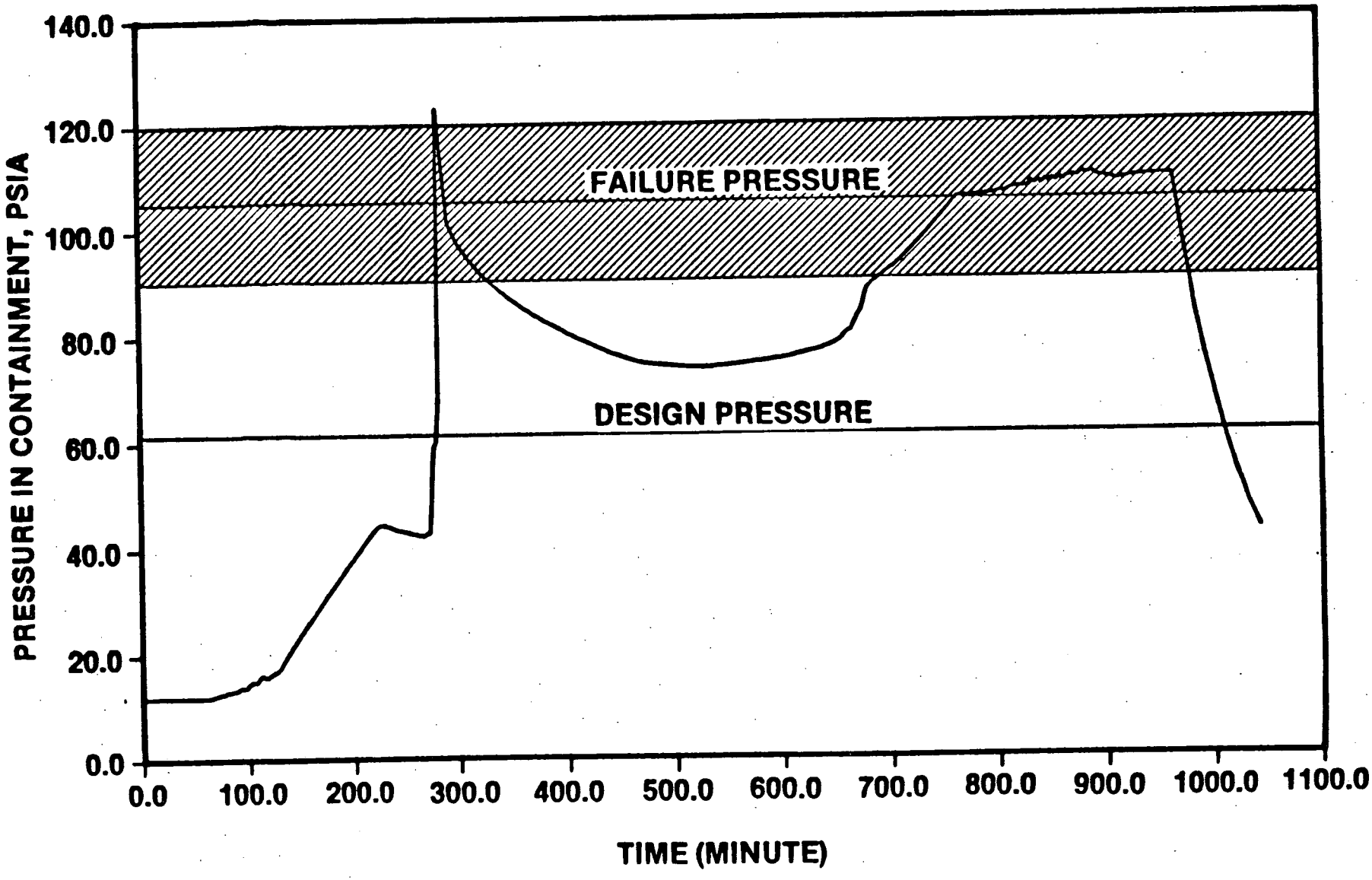
ECCS INJECTION CHARACTERISTICS AND POTENTIAL INTERACTION WITH MOLTEN CORE

	INDIAN POINT 2, 3		ZION 1, 2	
	ACCUMULATORS	LOW PRESSURE INJECTION	ACCUMULATORS	LOW PRESSURE INJECTION
WATER INVENTORY (LB)	173,000	2,890,000	219,000	2,800,000
OPERATING PRESSURE (PSIG)	650	250	650	300
FLOW CAPACITY (LB/MIN)	700,000*	24,000	700,000*	72,000
MAXIMUM CONTAINMENT PRESSURE INCREMENT (PSIG)	35	50**	40	50**
MAXIMUM CONTAINMENT PRESSURIZATION RATE (PSIG/MIN)	140	5	140	15

*BASED ON ZERO BACK PRESSURE.

**LIMITED BY THERMAL ENERGY OF MOLTEN MATERIAL.

CONTAINMENT PRESSURE HISTORY FOR TMLB'



PHENOMENOLOGY OF THE PRESSURE SPIKE

PHENOMENA	MAX. PRESSURE INCREMENT (PSIG)	PERTINENT ACCIDENT SEQUENCES
MOLTEN CORE SLUMPS INTO BOTTOM HEAD. STEAM IS RELEASED THROUGH SAFETY VALVE.	~15	TMLB', S_2D, S_2HF
REACTOR VESSEL FAILS. HIGH PRESSURE STEAM IS RELEASED TO CONTAINMENT.	~13	TMLB', S_2D, S_2HF
RESIDUAL WATER IN PRIMARY SYSTEM FLASHES OR IS FLUSHED INTO CAVITY.	~15	TMLB', S_2D, S_2HF
MOLTEN CORE FRAGMENTS IN CAVITY. WATER IN CAVITY IS VAPORIZED.	VARIABLE	AB, S_2HF
ACCUMULATORS DISCHARGE ONTO CORE DEBRIS IN CAVITY. ACCUMULATOR WATER IS VAPORIZED.	~35	TMLB', S_2D, S_2HF
CORE MATERIALS CONTACT CONCRETE. HYDROGEN IN CONTAINMENT IS IGNITED.	~60	AB, S_2D, S_2HF

ASSUMPTIONS LEADING TO RAPID PRESSURE SPIKE

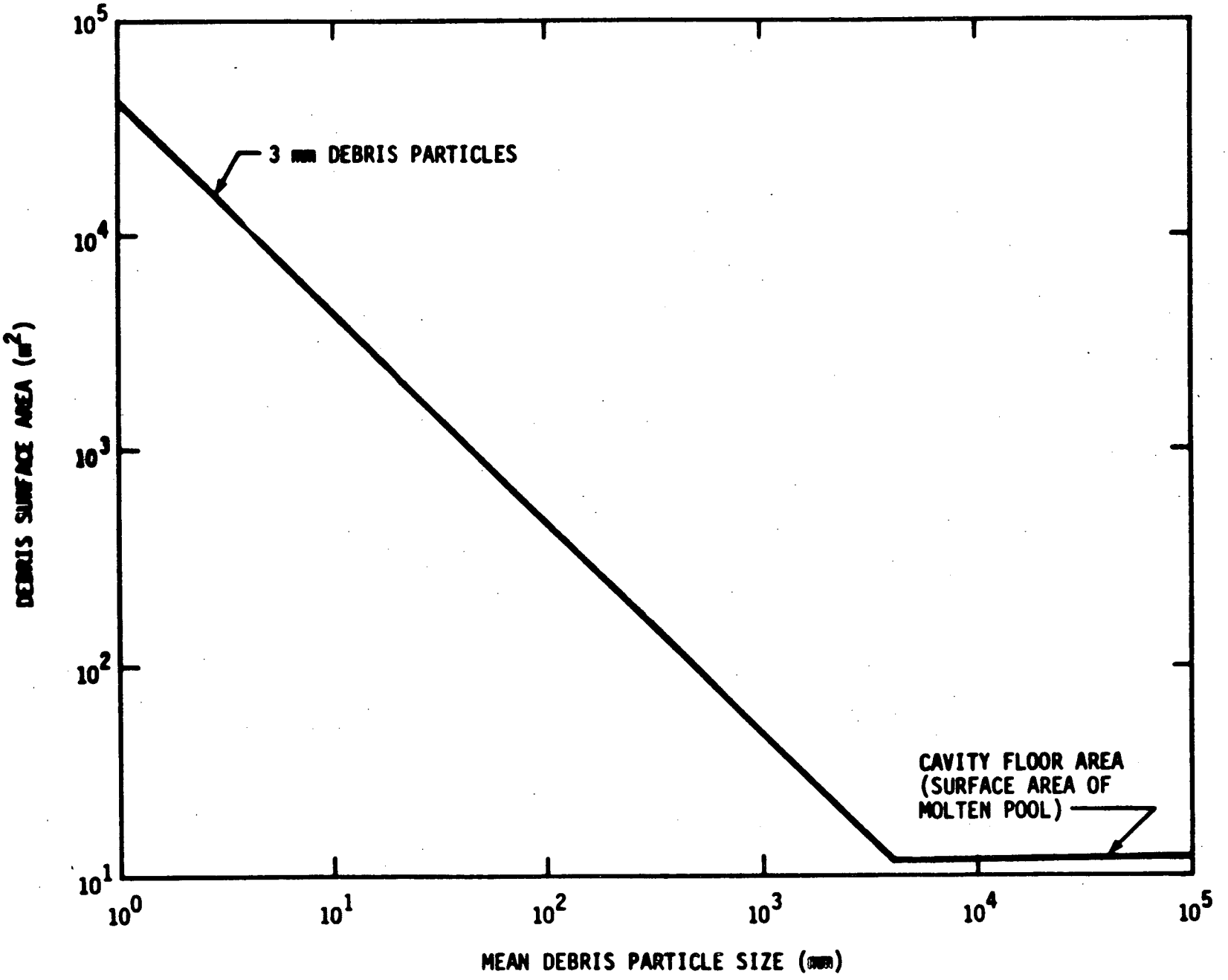
STEAM SPIKE

- VESSEL RUPTURE AREA IS LARGE
- CORE MATERIALS DROP RELATIVELY QUICKLY INTO CAVITY
- CORE MATERIALS FRAGMENT INTO SMALL PARTICLES (~3 MM MEAN MASS DIAMETER)
- CORE FRAGMENTS ASSUME A COOLABLE GEOMETRY (NO DRYOUT)

HYDROGEN SPIKE

- HYDROGEN IGNITION OCCURS AT ABOUT THE SAME TIME AS THE STEAM SPIKE

DEBRIS SURFACE AREA VERSUS DEBRIS PARTICLE SIZE



TIME AND MAGNITUDE OF THE PRESSURE SPIKE

ACCIDENT SEQUENCE	TIME AFTER INITIATOR (MIN)	INITIAL PRESSURE (PSIA)	FINAL PRESSURE (PSIA)	PRESSURE INCREMENT (PSI)
TMLB'	265	41	116	75
AB-BURN	51	42	135	93
S_2D-BURN	83	18	96	78
S_2HF-BURN	141	19	74	55

FACTORS WHICH COULD MITIGATE SIZE OF PRESSURE SPIKE

- INCOMPLETE CORE MELTING
- EARLY LOCAL FAILURE AT HEMISPHERE-CYLINDER JUNCTION
  - PRIMARY SYSTEM DEPRESSURIZATION PRIOR TO MELT THROUGH
  - PARTITIONING OF ACCUMULATOR WATER
- INCOMPLETE DEBRIS DUMPING
- EXPLOSIVE SCATTERING OF DEBRIS
- LARGE AMOUNTS OF SUBCOOLED WATER IN REACTOR CAVITY (>200,000 GAL)
  - CORE-WATER MIXING DYNAMICS
- SMALL AMOUNTS OF WATER IN REACTOR CAVITY
- CONTAINMENT COOLERS OR SPRAYS ON DURING HYDROGEN BURN
- HYDROGEN BURNS AS SOON AS IT BECOMES FLAMMABLE

FACTORS WHICH COULD INCREASE SIZE OF PRESSURE SPIKE

- INCLUSION OF LOOSE NON-MOLTEN STRUCTURAL MATERIALS IN DEBRIS
- OXIDATION OF MOLTEN STRUCTURAL MATERIALS

FACTORS WHICH COULD REDUCE RATE OF PRESSURE GENERATION

- CORE DRIBBLES INTO CAVITY OVER A PERIOD OF TIME
- LARGE MASS FRACTION COMPRISED OF VERY LARGE PARTICLES
  - REDUCED SURFACE AREA
- LARGE MASS FRACTION COMPRISED OF VERY SMALL PARTICLES
  - DEBRIS BED REMELTS
- POOR MIXING DYNAMICS