MEASUREMENT OF LOCAL PRESSURES RESULTING FROM HYDRODYNAMIC IMPACT

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The Primary goal of this project was a more thorough understanding of the influences of fluid-structure interaction

A recent test program conducted at Developmental Sciences, Inc., in the City of Industry, California involved the study of the effects of structural flexibility on the nature and magnitude of the loads that could result from a postulated loss of coolant accident (LOCA) in a nuclear power facility reactor. In the event of a LOCA, excess steam is injected into a pool of water, causing the water to impact the underside of a cylindrical shell structure.

A number of cylindrical steel shells ranging in size from 8.25" diameter x 38" long to 17" diameter x 80" long and having wall thicknesses from .036" to 1", were driven vertically downward into a pool of water to study the nature and magnitude of the pressures resulting from such an impact. A more thorough understanding of the influences of fluid-structure interaction and the applicability of certain scaling laws was the ultimate goal of the program.

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Because of DSI's previous experiences in the area of water impact testing, we were already familiar with the primary difficulty encountered in the measurement of extremely short duration hydrodynamic impacts. This is the tendency of most small, flush-mount diaphragm type pressure transducers to exhibit temporary spurious outputs upon initial contact with the water. This output typically lasts for 50 to 500 milliseconds (after which the transducers' outputs return to a stable "zero" level), and can be as much as 75% of the full-scale rated output of the transducers. This situation is obviously unacceptable, since the data of most interest occurs within 1 to 10 milliseconds after impact. This temporary unbalancing of the resistance bridge is apparently due to the difference in response of the individual bridge elements to the cooling effect of the water (which, even though at room temperature, temporarily cools the diaphragm because of its greater thermal conductivity).

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Our approach to solving this problem in past programs was a combination of three techniques: 1) we had the transducer manufacturer fill the transducer cavity with silicone oil - (giving the transducer greater thermal inertia, 2) we reduced the excitation voltage from the recommended 3 volts to 0.25 volts (which reduced the self-heating of the transducer by a factor of more than 100), and 3) we tested the transducers and selected those with the most desirable behavior.

The one sample that met our requirements was the Endevco 8510.

When the current test program began, we once again requested sample transducers for testing from eight manufacturers. All but one of the manufacturers' samples exhibited zero-shift problems when immersed. The one sample that met our requirements was the Endevco 8510. The apparent reason for this transducer's superior behavior when transferred between media of different thermal conductivities (and, we found, even different temperature), is the closely matched gages which result from Endevco's proprietary diffusion technique and the low power dissipation from the gages. All four elements thus exhibited identical thermal characteristics, and bridge balance is not upset by thermal changes.

Having selected the Endevco transducers for our program because of their excellent thermal characteristics, we purchased fourteen units and had them modified for our application. The modification consisted of removal of the protective screen covering the face and trimming of the body sides to within .002 of the face. This was done to present as flush a surface as possible to the impacting water.

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The DSI Water Impact Facility is separated from the instrumentation conditioning and data recording equipment by some 200 feet of cable. As this cable has significant capacitance we decided to perform a check of system frequency response. We wanted to extract the full benefit of the Endevco transducers' high-frequency response capabilities, and had rented an 80 kHz tape recorder. The transducer was simulated by a signal generator driving through a 1700 ohm resistor (to simulate the output impedance of the transducers. A loss of over 20 dB at 80 kHz was found. We then substituted a 100 ohm resistor, and found the resultant response to be within 1.5 dB at 80 kHz, and essentially flat over 50kHz. In order to reduce the effective output resistance of the transducers to 100 ohm, we shunted the output leads, at the transducers, with precision resistors of 106 ohm. This had the effect of reducing the full-scale output from approximately 300 mV to about 17 mV could tolerate the reduced output levels in exchange for the improved frequency response. A check of transducer linearity showed that the shunt resistors had no ill effect.

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The transducers used were of the 100 psig and 500 psig ranges in order to accommodate the very high peak impact pressures. The question arose as to whether the transducers could also respond accurately to the low (fractional psi) post-impact pressures at the lower test velocities. Tests revealed that at pressures as low as 0.1% of the transducers' rated range, the output was accurate to within less than 1%. This is truly remarkable performance!

Through the course of 20 months of testing, only four of the fourteen transducers failed - an amazing demonstration of durability under very demanding test conditions.

In conclusion, the Endevco Model 8510 pressure transducers proved themselves very well, with their outstanding thermal stability, good frequency response, excellent linearity and surprising durability.

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