Computational Fluid Dynamic Test Guide
For Providing Emergency Closing of a Water Based Oil Well

Computational Fluid Dynamic ("CFD") tests were conducted on the **Deep Sea Innovations' valve ("DSI valve")** to analyze the landing of the DSI valve onto a leak outlet to close the oil leak wherein the flow rate of the leak is five thousand gallons per minute (5000 gpm) from a nine inch (9 inch) I.D. outlet opening. The test addresses leaks at two ocean depths of twelve hundred feet (1200 feet) and ten thousand feet (10,000 feet). Test results conclude the DSI valve is designed to be successfully lowered through the turbulence of this leak flow and onto the origin outlet of the leak at the respective depths of 1,200 feet and 10,000 feet to close the leak. Navigational guides for the DSI valve are available, if needed, regardless of whether the well leak is positioned in very shallow water or in very deep water.

The DSI valve was tested at these depths as requested, however, it should be understood the same valve technology operates reliably and effectively to close wells whether they are in shallow water at fifty feet (50 feet) of depth or in deep water at thirty thousand feet (30,000 feet) of depth. The DSI valve utilizes closing forces generated by either ambient water pressure, if sufficient for that particular well, or with use of accumulator pressure should ambient water pressure not be sufficient. Thus, the DSI valve provides closure security of wells at all depths and provides the well owner the economic benefit of not having to re-drill a broken well.

With the DSI valve positioned on the outlet of the leak outflow, closure of the DSI valve will close the leak. The DSI valve piston head can be selected to employ the desired closure force needed to close the reservoir pressure of the particular well. At 10,000 ft. depth, the DSI valve with an 18 inch diameter head and 9 inch diameter arm will close a leak in excess of 17,000 psi reservoir pressure. Utilizing a 24 inch diameter head and 9 inch diameter arm will close in excess of 31,000 psi reservoir pressure. Alternatively, with a leak positioned at the 1,200 ft. depth an accumulator with a 4400 psi hydraulic force can be used in conjunction with the DSI valve having an 18 inch diameter head and 9 inch diameter arm for closing a leak in excess of 17,000 psi reservoir pressure. Similarly, utilizing the same accumulator with a 24 inch diameter head and 9 inch diameter arm will close a leak in excess of 31,000 psi reservoir pressure. Thus, selecting the head diameter along with the needed arm diameter, the DSI valve closure force can be selected utilizing either the available ambient water pressure for the particular well depth or with use of a selected accumulator hydraulic force.

The following test results demonstrates the forces confronting the DSI valve as it is lowered into position for closure of a well with 5000 gallons per minute of flow rate providing the reinforcement the DSI valve can be positioned onto this leak. The DSI valve with its unique oil pass through capabilities permits the valve to be navigable through the leak plume into a closing position. As mentioned above, additional navigation equipment is available, if needed. With the valve in position, the needed closing force of the valve is abundantly available, as mentioned above, to close the well and to re-open the well when needed. The repeated opening and closing of the well can be accomplished as needed with the DSI valve.

The following will be a guide through the Four Sections identified on **slide 3** of the CFD presentation.

SECTION ONE (slides 5 to 11)

shows the configuration of a leak plume at 10,000 feet of depth in the ocean. Differing velocities of the oil within the leak plume are colorized in accordance with the scale provided alongside each animated presentation.

Two velocity scales were used in the animated presentations. In the Leak Plume - High Flow Velocity Scale presentations, the colorization of velocities range from 0.00 feet per second to 39.97 feet per second. In the Leak Plume – Low Flow Velocity Scale presentation, the colorization of velocities range from 0.00 feet per second to 6.65 feet per second. The two tests represent the same velocity data, except in the Lower Flow Velocity Scale presentation all velocities at and over 6.65 feet per second result in those velocities all being the same color, magenta. With substantially most of the flow velocities within the leak plume being represented in the same color in the "The Leak Plume - Lower Flow Velocity Scale" presentations, the viewer is provided more visual clarity and resolution to the leak plume configuration.

In this section, two tests were run, one for a cold and one for a hot oil temperature. It was determined from the data obtained, the most turbulent portion of the leak flow occurs at approximately eleven feet (11 ft.) elevation above the outflow outlet. The final graph of this section depicts the flow velocity of the leak flow as it progresses away from the leak flow outlet. In this graphical representation, the leak flow outlet is positioned ten feet (10 ft.) above the ocean floor. The graph at **slide 10** compares the velocity flow profile for each of the hot and cold oil leak flows.

SECTION TWO (Slides 13 to 17)

shows the configuration of a leak plume at 1,200 feet of depth in the ocean having the flow rate of 5000 gallons per minute (5000 gpm). Differing velocities of the oil within the leak plume are colorized in accordance with the scale provided for each presentation. The two presentations were both run for cold oil. The leak plume at this depth was noted to have a similar size and similar position of maximum turbulence, as the leak plume in Section 1, with the leak having the same flow rate and originating at 10,000 feet of depth. The leak flow rate appears to be the most significant factor in the formation of the resulting leak plume size and flow velocity and not the depth at which the leak occurs. The graph at **slide 16** compares the flow velocities of the leak plume for the 1,200 and 10,000 foot depth leaks at the same elevations above the leak outflow outlet. In these presentations the leak outflow outlet is positioned at ten feet above the ocean floor.

SECTION THREE (Slides 19 to 27)

demonstrates what forces the DSI valve experiences in the leak flow (5000 gpm) at the 10,000 foot depth with respect to two locations positioned within that leak flow. The first location is shown in **slide 19** wherein the DSI valve is positioned at the most turbulent elevation of eleven feet (11 ft.) above the outflow and is positioned centered over the outflow outlet. **Slide 20** portrays the vertical forces exerted on the DSI valve over time and **slide 21** portrays the lateral forces exerted on the DSI valve over time, both at this first location. **Slide 22** portrays the twisting moment exerted on the DSI valve also at this first location. The second location is shown in **slide 23** wherein the DSI valve is positioned again at the eleven foot (11 ft.) elevation above the outflow outlet but is additionally offset laterally one pipe diameter from the centerline of the outflow outlet. Similarly, **slides 24** and **25** portray the vertical forces and the lateral forces exerted on the DSI valve over time at this second location. **Slide 26** portrays the twisting moment exerted on the DSI valve also at this second location.

SECTION FOUR (Slides 29 to 37)

demonstrates what forces the DSI valve experiences in the leak flow (5000 gpm) at the 10,000 foot depth with respect to two additional locations positioned within that leak flow. The first location is shown in **slide 29** wherein the DSI valve is positioned at a one foot elevation above the outflow outlet and in alignment with the centerline of the outflow outlet. **Slides 30** and **31** portray the vertical forces and the lateral forces exerted on the DSI valve over time both at this first location. **Slide 32** portrays the twisting moment exerted on the DSI valve also at this first location. The second location is shown in **slide 33** wherein the DSI valve is positioned again at the one foot elevation above the outflow outlet but is additionally offset one pipe diameter from centerline of the outflow. Similarly, **slides 34** and **35** portray the vertical forces and the lateral forces exerted on the DSI valve over time at this second location. **Slide 36** portrays the twisting moment exerted on the DSI valve also at this second location.

CONCLUSION

The DSI valve can be lowered into a leak outflow of 5000 gallons per minute. The forces the DSI valve will encounter will permit the valve with a payload of approximately fifty tons to be navigated and maintained on course in order to engage the leak and close the leak.

The DSI valve is navigable within this leak flow in a number of ways. In one approach, the DSI valve is guided onto the outlet with use of at least a portion of the leak flow passing through the DSI valve. The flow exits the up-turned vent pipes of the DSI valve and impacts one or more of four symmetrically positioned adjustable guide plates of the DSI valve positioned above the vent pipe outflows. The leak flow selectively impacting adjustable guide plates will generate a reactive course changing force of the descending DSI valve. In another approach the DSI valve can employ other navigational steering which includes mechanical guide equipment which locks onto the outlet and mechanically guides the DSI valve being lowered onto the leak outlet. Additional guidance systems can also be employed.

Appendices - The test parameters and conditions are summarized.