Abstract Interspill: Field Data Provides Evidence that Subsea Dispersant Injection Protected Responders during the Deepwater Horizon Oil Spill

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Protecting the safety and health of responders is the top priority for any emergency response operation including oil-spill response. Decision makers made a crucial decision during the 2010 Deepwater Horizon (DWH) disaster to inject dispersants at the wellhead (Sub-Sea Dispersant Injection, SSDI). One goal of SSDI was to minimize volatile organic compound (VOC) exposure of the responders working on surface vessels near the well (Drieu et al., 2011). BP and subsequently NIOSH (National Institute for Occupational Safety and Health) set conservative VOC exposure limits for responders working on these vessels (Ahrenholz and Sylvain, 2011). This tragedy, which killed 11 men, led to oil being released at the 1500 m deep seabed a distance of over 60 km from the Louisiana coast (Read, 2011; Barbier, 2015). The spill started on April 22, 2010 and lasted until July 15, 2010. We used a very simple statistical approach to analyze a vast amount of publicly available atmospheric VOC data collected on vessels during the Deepwater Horizon tragedy to determine if SSDI protected worker health by limiting exposure to VOC.

Our analysis included over 90,000 VOC measurements obtained from dozens of instruments on 20 response vessels supporting well-control operations near the MC252 oil. We found that subsea dispersant injection (SSDI) caused a statistically significant reduction in airborne VOC concentrations in a dose-dependent manner, that elevated VOC levels on ships' decks were diminished ($p<0.001$), and peak VOC concentrations (>50 ppm VOC) that could have been an immediate concern to worker health were reduced by a factor of ~6 to 19 when dispersants were delivered at a sufficient rate.

We analyzed several 'what if?' scenarios relevant to any future use of SSDI. How much higher might potential exposure have been without SSDI? How much lower could exposure have been if injection had routinely achieved the highest rates use (>10 GPM)? How much lower could exposure have been if SSDI had been started as soon as technically feasible (we assumed this to be the start of our VOC collection data (May 1))? We did this using a metric of cumulative normalized VOC-hours determined from the hourly VOC measurements made on the dozens of instruments on the 20 vessels stationed near the well site. Cumulative normalized VOC-hours were determined each hour by summing the VOC concentration (measured VOC concentration – 50 ppm) for each detector whenever readings were over 50 ppm and then accumulating these sums over time. VOC-hours were normalized by dividing each calculated VOC hour by the number of detectors in operation for that hour to account for the significant changes in the number of detectors collecting data over the course of the spill.

Fig. 1 shows a graph of the various scenarios we analyzed. The black line plots the cumulative exposure (VOC-hours) above the 50-ppm threshold using the actual data with interpolation of appropriate average data for the few hours with no measurements. The red line is our prediction for the cumulative normalized VOC-hours for no SSDI using an average normalized VOC-hour (45.4) from all the SSDI = 0 data, and the green lines use our estimate for the >10 GPM (the highest dispersant injection rates) case using an average normalized VOC-hour (2.8) from all the SSDI >10 GPM data (which actually averaged 10.4 GPM over 90 hourly injection rates in the range of 10.03-13.2 GPM). We generated two SSDI > 10 GPM scenarios by assuming SSDI started on either May 15 (SSDI day 0) or May 1 (the start of VOC data in the data set available to us).

SSDI as delivered during the spill clearly reduced the potential for worker exposure to VOC over 50 ppm. This was by about 37% from May 15 (when full operational use of SSDI began), and would have been 48% if the injection rate had been at >10 GPM throughout this period. A 94% reduction of VOC >50 ppm was predicted if SSDI at rates above 10 GPM had been initiated and maintained on May 1.

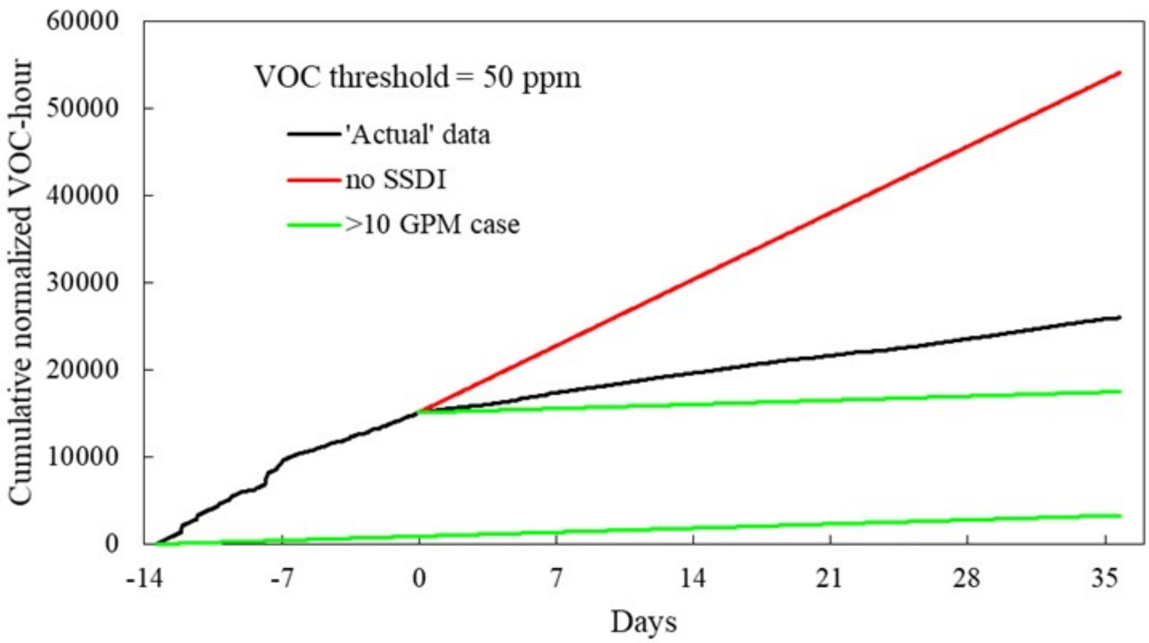

Figure 1. Cumulative normalized VOC-hour (threshold 50 ppm) for potential SSDI scenarios. The 'Actual' data are the measured data (we used an average normalized VOC-hour for the small number of hours missing data before and after Day 0). The scenario of no SSDI was the cumulative of average VOC hour of no SSDI, projected from Day 0. The '>10 GPM case' scenarios used the average VOC hour for SSDI > 10 GPM projected from Day 0 or Day -14.

Findings from this analysis differs from others that were based on model simulations. We believe that our approach of using field data to assess SSDI is more accurate than model simulations. Further, our findings are not only strengthened by the large number of measurements we analyzed but also by the large number of VOC measurements made before SSDI was initiated. This allowed use of straightforward statistical tools to assess correlation of VOC with SSDI. Further still, the dose dependence of VOC with SSDI rates strongly suggests causation and not just correlation. These findings indicate that decision makers and contingency planners should include health and safety considerations for decisions on the use of subsea injection of dispersants.

The oil industry has established a global subsea response network that includes pre-staged portable deep-water capping stacks that could cap a damaged well in days rather than months

(Cuthbert, 2018; Oil Spill Response 2021). In addition, there are dispersant and equipment stockpiles in strategic locations around the world to rapidly implement SSDI if necessary. Our findings provide evidence that SSDI should remain an important component of contingency plans for future offshore oil drilling operations.

Additional details on this study can be found in Zhao et al. (2021).

References

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