

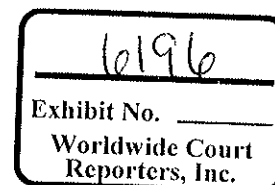
Some of this could be used for response to Mike Bowman

Considerations of flowrate from MC252

Trevor Hill, August 17

Initial comments

- Scale of response to the spill was not affected by flowrate estimates
 - Marcia MacNutt, May 27... 'We have not been constrained by flowrate estimates. The scale of the response would have been the same regardless if it were 1000 barrels a day or 100 times that'...
- Direct measurement of flowrates of oil and gas in a two phase flow is difficult under ideal conditions, and was not practical at the riser plume in the seabed trench or at the kink leaks
- Early work to collect data on the system was focussed on pressure upstream and downstream of BOP
- Subsequent plans to collect oil from the wellhead came with direct oil flowrate measurement included, so effort to measure flow indirectly became less significant



Early flow rate estimates

- BP has not to date developed a formal estimate of flow rate or produced volume
- Estimates made by external organisations are as follows:
 - 1 Mbd, Apr 23
 - 5 Mbd, NOAA, Apr 28
 - 12-19 Mbd, FRTG, May 25
 - 20-40 Mbd, FRTG, June
 - 35-60 Mbd, FRTG, June
 - 53-62 Mbd, DOE, August 1
- These estimates result from several techniques of varying accuracy
- There are several reasons why it is likely that flowrate increased significantly between April 22 and July 15

Flowrate dependencies

- Flowrate from MC252 to GoM since April 22 is a function of:
 - Reservoir pressure
 - Inflow from reservoir to well
 - Flowpath through well (casing and drillpipe)
 - Flowpath at top of well (through Horizon BOP and riser, and latterly through 3 ram stack)
 - Fluid properties
 - Vessel collection rates

What changed during the time period?

- Reservoir pressure has declined
- Inflow performance has probably changed as the well cleaned up
- Flowpath at top of well has changed on numerous occasions, mostly reducing back pressure
- Collection rates to vessels have changed on numerous occasions
- Therefore flowrate from MC252 to GoM has been changing continually
- Total volume discharged from MC252 to GoM will require detailed consideration of dependencies and variations over the complete time period

Methods required

- Reservoir modelling
- Inflow performance modelling
- Wellbore and riser hydraulic modelling
- Detailed 3 ram stack piping, choke, and Horizon BOP hydraulic modelling
- Fluid properties as a function of pressure and temperature
- Measured pressures and vessel collection rates

Water column
• Plume modelling

- Video analysis & discharge

Information required from yet-to-be recovered components

- Length and nature of drillpipe sections in BOP, and therefore the flowpath through the kink
- Condition of BOP rams and annulars, and therefore the flow area and restrictions for flow outside the drillpipe
- Nature of riser in buried sections, in which there may be considerable flow area reductions

Estimate of flowrate on July 14/15

- Information from preparation and execution of well integrity test may be used to estimate flowrate from MC252 to GoM on July 14/15
 - Pressure in 3 ram stack was measured for different collection rates into HP and Q4000, and different flowpaths through the 3 ram stack
- The flowrate estimate may be made by:
 - Prorating against different vessel collection rates (taking into account variation in pressure drop over Horizon BOP)
 - Direct calculation by modelling of 3 ram stack piping

Uncertainties in July 14/15 flowrate estimate

- Pressure gauges in close proximity show matching trends but different values
 - Statement in preparation to identify the most accurate measurement, and the associated uncertainty
- Vessel collection rates show trends but with uncertainties in accuracy
 - Investigations under way into accuracy and uncertainty of both Q4000 and HP oil collection rates
- Seabed ambient pressure required for pressure drop also has some uncertainty

BP estimate of flowrate on July 14/15

- BP has prepared models of 3 ram stack piping hydraulics and a model for prorating of different collection rates and pressure drop over Horizon BOP
- Formal BP estimate of flowrate on July 14/15 can be made once input data audit trails and accuracy/uncertainty are defined

Government July 14/15 flowrate estimate

- Government science team have used the preliminary pressure and collection rate information to estimate flowrate on July 14/15 as ~53,000 bpd
- It is not known whether they used the preliminary or interim values of pressure and flowrate
- In any case they will need to update their estimate once the audit trails on the measurements are completed

Estimate of produced volume over the whole period

- Reservoir modelling is under way, but depends on iterations with the flowrate estimate
- Inflow performance changes will be estimated from initial rate during the incident and final rate on July 14/15
- Wellbore and riser hydraulic models are in place, but awaiting details of flow path through BOP and kink
- Detailed 3 ram stack piping, choke, and Horizon BOP hydraulic modelling is in place but will be refined as pressure measurements are better characterised
- Fluid properties as a function of pressure and temperature are available and are being checked against oil and gas collection data

Government estimate of produced volume over the whole period

- Government science team have used the preliminary pressure and flow information to estimate produced volume (4.9 million barrels), apparently only taking into account reservoir depletion and two cases of back-pressure change
 - Reservoir pressure change from 11850 to 10300 psi
 - 4% increase in flowrate on June 3 from cutting riser
 - 4% decrease in flowrate on July 12 due to installation of 3 ram stack
- This estimate does not take into account many of the changes to back pressure, nor variations in inflow performance, nor the flowrate estimated for the incident, each of which BP believes to be potentially significant