Ichthys: trouble in the pipeline?

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Oil corporation Total released the following statement a few days ago, upon selling 4% of the Ichthys field to Inpex for US$1.6 billion*: "Ichthys is part of a wave of Australian LNG projects, which have unfortunately experienced major cost overruns and delays during their construction phase."*

The transaction amount is consistent with the reported capital expenditure so far, which is US $40 billion.

However, it would not be surprising if the real reason for Total to divest was other, such as the technical choice of piping a mixture of natural gas, ethane, propane, butane, nitrogen and carbon dioxide after having removed offshore only about 85% of the condensate.

Quite likely, this technical choice could prove quite nefarious in the future and it has the potential of strongly affecting productivity at the LNG plant in Blaydin Point. Commonly, wet gas is dried almost completely prior to piping and all compounds other than methane are removed as much as possible..

Inpex issued an *"Ichthys Project Gas Export Pipeline (Operation) Environment Plan Summary"*, which was the document submitted to the Australian National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). The technical aspects of the document are quite irrational at times and it is surprising that it passed the scrutiny of NOPSEMA.

Of particular interest is paragraph 2.2.1. See excerpts below in green. Comments are in blue. Almost each and every paragraph contains at least one gross error.

> *GEP gas will normally be in 'dense phase' (i.e. heated and compressed above its critical temperature and pressure, such that it becomes a dense, highly compressed fluid that demonstrates properties of both liquid and gas), and will travel through the GEP, from the Offshore Facility to the Ichthys LNG Plant.*
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> > Although the explanation of the *'dense phase'* behavior is more or less accurate but simplistic, since no fluid can really behave at the same time as a gas and as a liquid, for a gas is compressible and a liquid is not, the conditions in the pipeline will not be as described here, and in particular the temperature will be much lower than critical temperature.
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> *The transfer of dense phase gas via a pipeline is uncommon in Australian waters. However, it is a requirement for this activity due to the length of the GEP and the required inlet pressure at the Ichthys LNG Plant.*
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> > There is a very good reason for commonly removing all liquids beforehand and piping only the purest possible gas, as shown below. Furthermore, if anything, the extensive length of the pipeline should be a deterrent, not an

incentive, to piping a mixture, and the argument of the inlet pressure at the LNG plant is quite irrelevant.

The GEP is a 42-inch outer diameter, steel pipeline, installed with concrete weight and asphalt enamel external coating. The concrete coating provides a degree of protection for the GEP's integrity against potential impacts, such as from dropped objects or fishing gear. The GEP has been installed with 5 hot-tap-tees and one midline dummy spool, all with 'over-trawl' covers installed.

In passing, the purpose of the concrete coating is not to provide any *"integrity against potential impacts"*, but to force the pipeline to sink. This being said, the pipeline can probably sustain over 300 bar so damaging it would be quite a feat, and the concrete coating will provide extra protection.

GEP gas consists of Ichthys Field reservoir hydrocarbons which have been processed on the CPF and FPSO to remove most of the water and long-chain hydrocarbons. The GEP gas consists primarily of natural gases with a minor fraction of light condensate (C5–C13), a very light oil, when at ambient temperature (25 °C) and pressure (1 bar). The expected components of GEP gas are provided in Table 2-1. For the Ichthys GEP, dense phase will be achieved only by high pressure and the temperature will be that of the ambient seawater.

Contrary to the statement in the first part of paragraph 2.2.1, it is said here that the *"dense phase"* will be achieved by pressure only, not by temperature. Because of this, a fine analysis of the phases shows that carbon dioxide will be in the liquid phase, and so will be condensates, ethane, propane, and butane. Only methane and nitrogen will be in a gaseous phase.

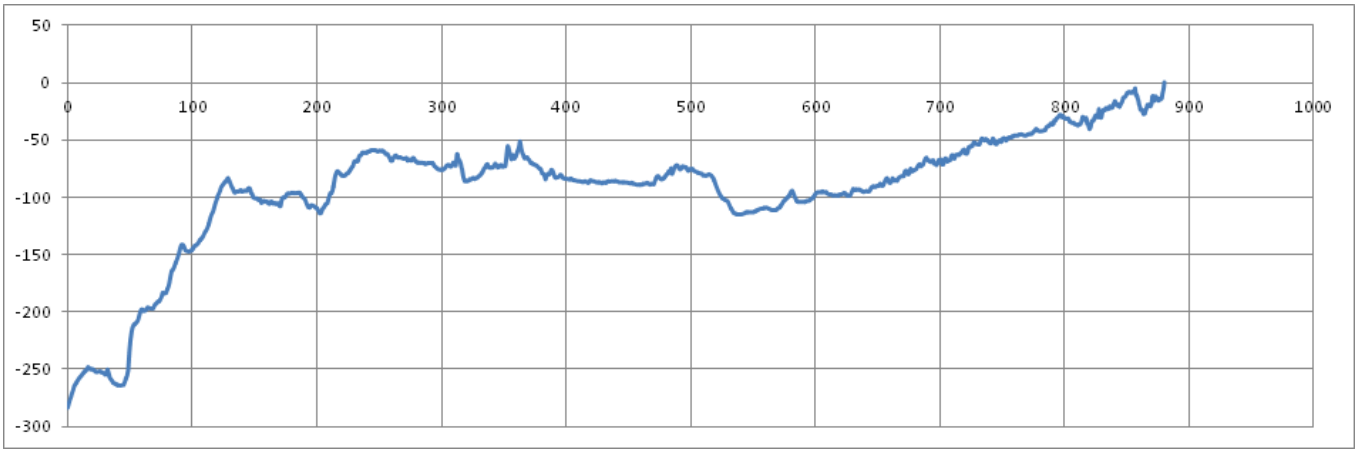
The GEP will typically operate with an inlet pressure of approximately 200 bar on the offshore end. Due to the 889 km length of the GEP, a significant pressure drop will occur as the gas transits towards the Ichthys LNG Plant, because there are no compressors along the GEP. The inlet pressure at the Ichthys LNG Plant boundary (the onshore end of the GEP) will typically be between 65 bar and 110 bar. Because of the very high operating pressures, the GEP gas will normally be in dense phase, hence no liquid hydrocarbons will be present within the GEP while operating. It is estimated that at any moment in time, the GEP will contain approximately 10 000 m^3 of condensate (C5–C13) if it were processed th6rough [sic] the Ichthys LNG Plant and stabilised to ambient temperature and pressure.

The pressure alone is not sufficient to ensure that liquids will not be present, and since ambient temperature in the pipeline will probably be of the order of 15 C, liquids will be present. In fact about 7,600 m^3 of condensate will be present in the pipeline, which is reasonably close to 10,000 m^3. The transit time through the pipeline will be about 4 days, which means that temperature will indeed be quite close to underwater ambient temperature.

Table 2-1: Expected GEP gas composition

Component	***Mol (%)***
Methane (C_1)	*72.92*
Ethane (C_2)	*10.60*
Propane (C_3)	*4.24*
Butane (C_4)	*1.87*
C_5–C_7	*1.10*
C_8–C_{13}	*0.03*
Carbon dioxide (CO_2)	*8.71*
Nitrogen (N_2)	*0.50*
Water (H_2O)	*<0.01*
Hydrogen sulfide (H_2S)	*<0.01*

Ichthys pipeline profile:



A fine analysis of the profile shows that 765 of the 889 km of the pipeline is U-shaped, which means that in case of flooding by liquid phases 87% of the pipeline will remain filled with liquids that won't naturally evacuate, except by evaporation if the pipe be depressurized and overall pressure dropped below 2 bar. The fluid inside the pipeline will in fact not remain as a *"dense phase"* fluid at all times, for temperature will not be

high enough, and part of the pipeline content will be in a liquid form. The average density will be between 265 kg/m^3 at the inlet and 85 at the outlet, which would represent a static head loss of between 7 and 2 bar since the vertical rise is 250 m, and, should the pipeline flood with liquid LPG, that head loss would be about 15 bar. The inlet pressure of 200 bar would allow the transit of gas in all cases, but overall dynamic turbulent head loss through the liquids could be such as to reduce the outlet pressure to unacceptable values and force the flow of gas to be severely reduced, thus negatively impacting productivity.

May Jesus Christ, Son of God, be the Savior of Inpex. Pardon the facile pun.