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September 20, 2006

Australian Pipeline Trust

PO Box 934

MASCOT, NSW 2020

Attention: Mr Stuart Ronan

Dear Stuart:

RE: PIPELINE CAPACITY VARIATION WITHY GAS COMPOSITION

You requested advice on the appropriateness of equations proposed to factor the change in pipeline capacity with gas composition.

APT use the following equation:

$$\text{APTPPL's obligation} = MDQ*[1 + 0.020*(AHV - 40)]$$

ACCC has proposed a modified equation:

$$\text{APTPPL's obligation} = MDQ * (AHV2/AHV1) * \sqrt{(RD1/RD2)}$$

Where:

MDQ = Maximum daily quantity
AHV = Actual Heating Value
RD = Relative Density (specific gravity)

To test the equations, Venton used a steady state compositional hydraulic model (Flowtran) to determine the steady state capacity for a DN 400 pipeline, 400 km long, operated at a fixed inlet pressure of 10.0 MPa and a fixed delivery pressure of 4.5 MPa. This simple model was chosen because it avoided the complication introduced by compression with spare power.

Calculations were undertaken for 7 gas compositions, some real and some manufactured to reflect a range of "typical" compositions between essentially pure methane (Fluid G) and a composition provided by APT as representing a gas whose heating value is close to the reference gas with a heating value of 40 MJ/scm (Fluid F).

An additional gas composition (Fluid H) which represents a composition proposed for the PNG Sales Gas is included in the comparison to extend the comparison above the reference gas GHV. Composition details of this gas is not reported.

The calculation reported the pipeline capacity in TJ/d.

The BWRS equation of state provided with Flowtran was used to calculate relevant compositional data, including specific gravity, density and gross heating value. This data is shown in Table 1 and Figure 1 attached to this letter.

Calculation Output – UnCompressed Pipeline

The output from these calculations is presented in Figures 2 – 5 attachments to this letter.

The throughput calculated using the ACCC equation refers to the properties of Fluid F (HHV = 39.66 MJ/scm and SG = 0.629 as the base composition.

There is no clear conclusion from the comparison as described below:

1. When plotted against Heating Value (Figures 2 and 3) the ACCC equation follows the shape of the calculated throughput more closely than does the APT equation at lower heating values, while the APT equation follows the calculated heating value more closely at higher heating values.
2. When plotted against the Specific Gravity (Figure 4) the ACCC is higher than the calculated capacity while the APT equation is lower than the calculated capacity by approximately the same value for gas SG's lower than about 0.63n while the APT correlation better predicts the calculated throughput at higher SG's.

Compressed Pipeline

While the calculation was done in steady state flow for a pipeline without intermediate compression, the result of the comparison generally applies to a compressed pipeline, although there will be some variability principally because the average pressure across each pipe section (between compressors) is higher, and the supercompressibility at the higher average pressures will vary for each gas composition. Several calculations were undertaken using a model of the RBP in its current configuration and a similar capacity variation with composition resulted. However, great care is required to get comparable results because:

1. The compressors try to adjust for differences in the hydraulic performance of the pipeline and;
2. Changes in compressor power alter the quantity of fuel gas transported in the pipeline, affecting the capacity available at the delivery point.

In a real pipeline like the RBP operating with significant weekly transients it is probable that the weekly gas delivery will be reduced significantly because:

1. The gas storage volume after the weekend re-compression period is reduced by the changed supercompressibility. For example at 8 MPa and 15°C, the supercompressibility of gas G is 0.8527, while the supercompressibility of gas F (the reference gas in this assessment) is 0.8143. This represents a reduction in storage capacity of 4.5%.
2. The energy of the stored gas is reduced by the relative heating values – using gas G (37.75 MJ/scm) and gas F (39.66 MJ/scm) the reduction is a further 5%.

The combined effect of the two components results in a potential reduction in the energy stored of approximately 10%. Because gas G contains no inerts, the effect from coal seam methane from a real gas source could be higher.

Generalised Correlation

Pipelines transport volume, not energy.

Gas pipeline hydraulics expressed on an energy basis is complex because the heating value, gas SG and gas supercompressibility varies with the composition and the quantity of inert components in the gas. The supercompressibility and density directly impact on the pipeline throughput while the delivered energy is computed by applying the specific energy to the gas volume delivered.

There may be merit in deriving a more general equation that better reflects the inter-relationship between composition an delivered energy. Applying the data to a multivariable regression program results in the following equation as a best fit:

$Y = a+b*x_1+c*x_1^2+d*x_1^3+e*x_1^4+f*x_1^5+g/x_2$

Where:

X_1 = GHV (MJ/scm)

X_2 = Specific Gravity

a = -67994180.85

b = 8757879.84

c = -450891.431

d = 11598.29048

e = -149.0591962

f = 0.7656853174

g = 112.260464

The maximum error in the above equation is less than 0.2% in predicting the delivered energy using values of GHV and SG.
However the equation is complex and unless there is a real need for an accurate prediction of the capacity impact, it seems that the APT equation should continue to be used, particularly since it is more favourable to producers who supply lower heating value gases.

If APT or ACCC wishes to explore a more general relationship further, the Flowtran computation should be run for a broad range of compositions that historically have been supplied to the RBP, as well as those projected to be supplied, and the data analysed by an appropriate curve fitting program to develop a generalised relationship.

We can provide that service should it be required.

Sincerely,
VENTON & ASSOCIATES PTY LTD

Philip Venton

Table 1 - Gas Properties

Name of Calculation	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp	C:\FlowTran\Venton\RBP-176\Development\DN400 Vary GHV_Gas G.inp
Name of Gas Mixture	**Fluid G**	**Fluid F**	**Fluid E**	**Fluid D**	**Fluid C**	**Fluid B**	**Fluid A**
Gas Name	**Mole Fraction**	**Mole Fraction**	**Mole Fraction**	**Mole Fraction**	**Mole Fraction**	**Mole Fraction**	**Mole Fraction**
Methane	0.99950	0.890	0.960	0.902	0.921	0.909	0.990
Ethylene	0.00000	0.000	0.000	0.000	0.000	0.000	0.000
Ethane	0.00000	0.059	0.004	0.050	0.051	0.051	0.000
Propane	0.00000	0.013	0.001	0.011	0.005	0.007	0.000
i-Butane	0.00000	0.003	0.000	0.001	0.000	0.002	0.000
n-Butane	0.00000	0.002	0.000	0.002	0.000	0.001	0.000
i-Pentane	0.00000	0.001	0.000	0.001	0.000	0.000	0.000
n-Pentane	0.00000	0.001	0.000	0.000	0.000	0.000	0.000
n-Hexane	0.00000	0.001	0.000	0.001	0.000	0.001	0.000
n-Heptane	0.00000	0.000	0.000	0.000	0.000	0.000	0.000
n-Octane	0.00000	0.000	0.000	0.000	0.000	0.000	0.000
Nitrogen	0.00025	0.013	0.032	0.011	0.015	0.021	0.005
Carbon dioxide	0.00025	0.018	0.002	0.022	0.007	0.009	0.005
Hydrogen sulfide	0.00000	0.000	0.000	0.000	0.000	0.000	0.000
% Inerts	0.05	3.1	3.4	3.3	2.2	3.0	1.0
Mix Property	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Molecular Weight kg/mole	0.0161	0.0182	0.0166	0.0180	0.0173	0.0176	0.0162
Standard Gravity	0.5541	0.6290	0.5725	0.6223	0.5968	0.6091	0.5606
CalorifValue MJ/Sm3	37.7461	39.6614	36.6842	39.0786	38.6942	38.8806	37.3873
Wobbe Index MJ/Sm3	50.7085	50.0067	48.4829	49.5399	50.0870	49.8165	49.9324
Thermodynamic Property	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Pressure kPaa	101.3	101.3	101.3	101.3	101.3	101.3	101.3
Fluid Temp C	15	15	15	15	15	15	15
Density kg/m3	0.6803	0.7727	0.7029	0.7643	0.7330	0.7481	0.6884

Figure 1 - Gas HHV Plotted against SG

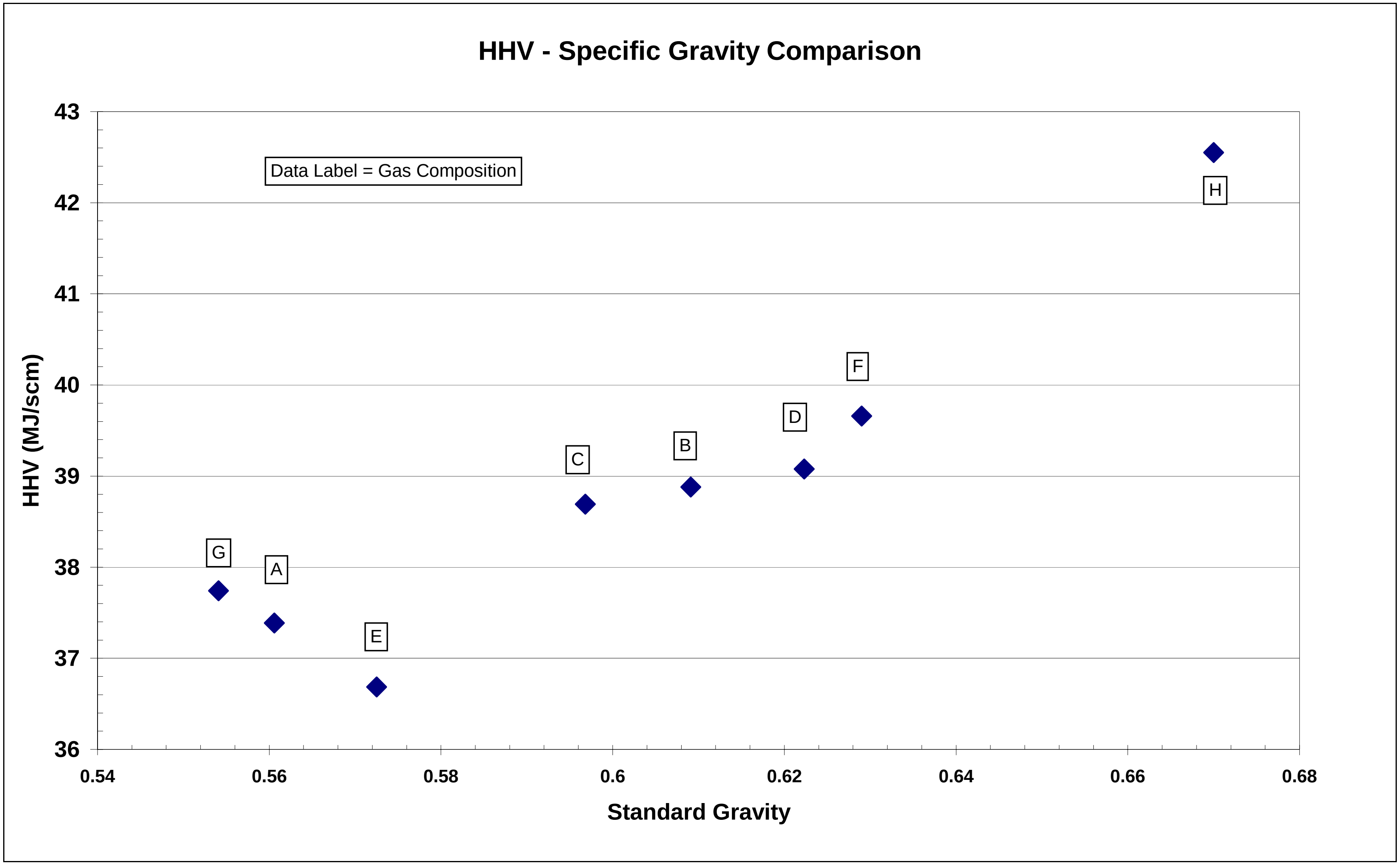

Figure 2 - Comparison - Calculated and Predicted Pipeline Throughput - APT Equation

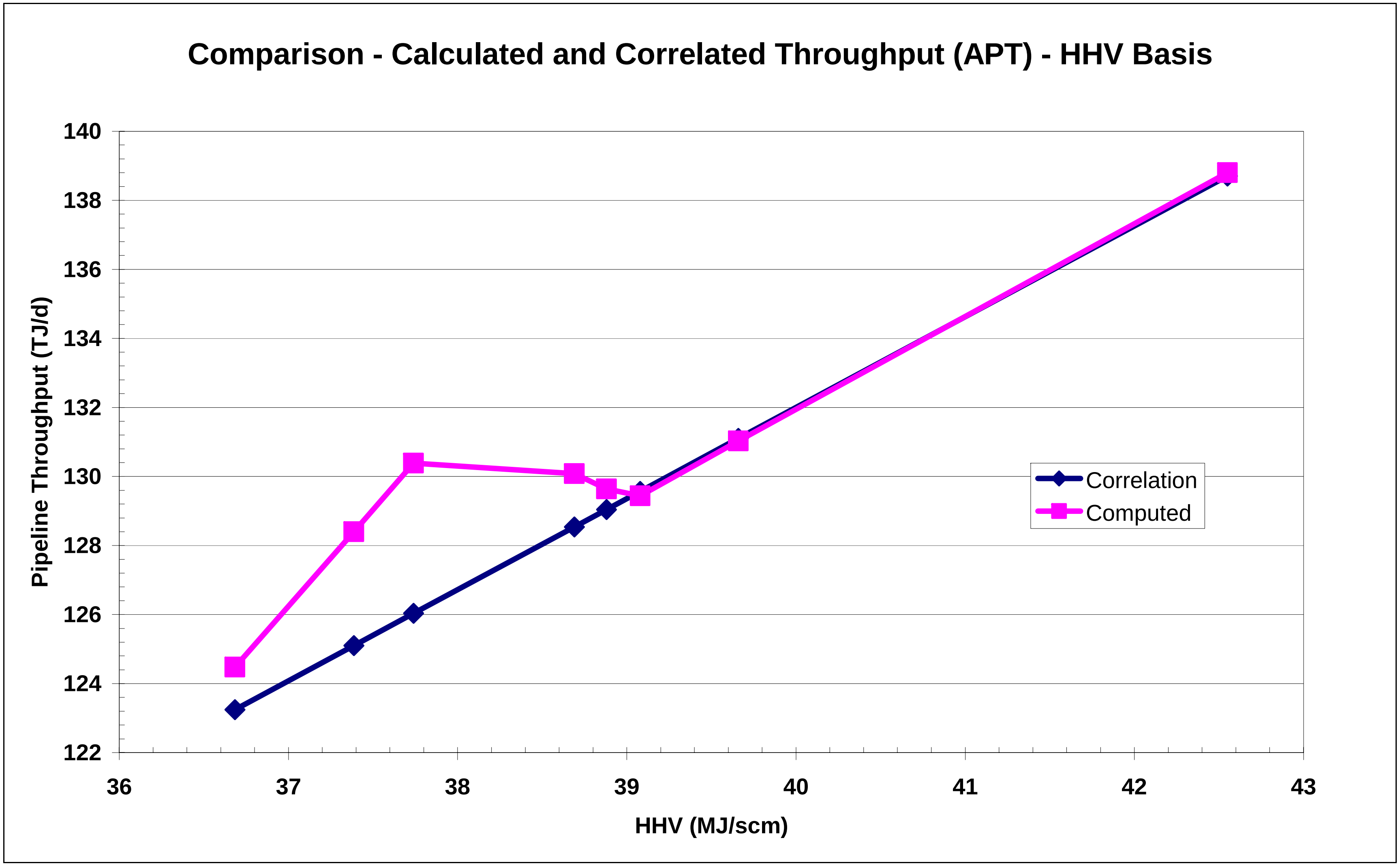

Figure 3 - Comparison - Calculated and Predicted Pipeline Throughput - ACCC Equation

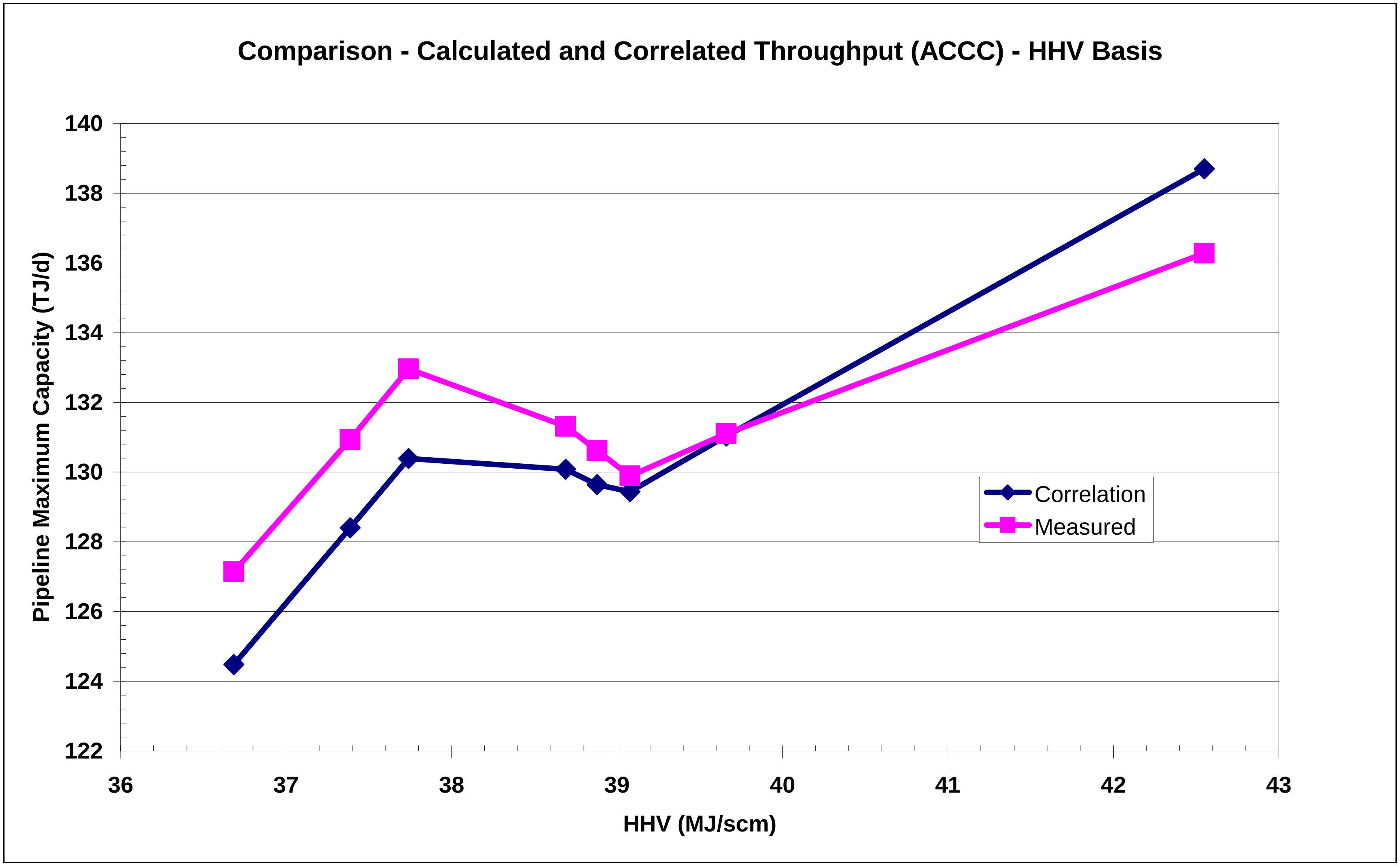

Figure 4 - Comparison - Calculated and Predicted Pipeline Throughput - ACCC Equation

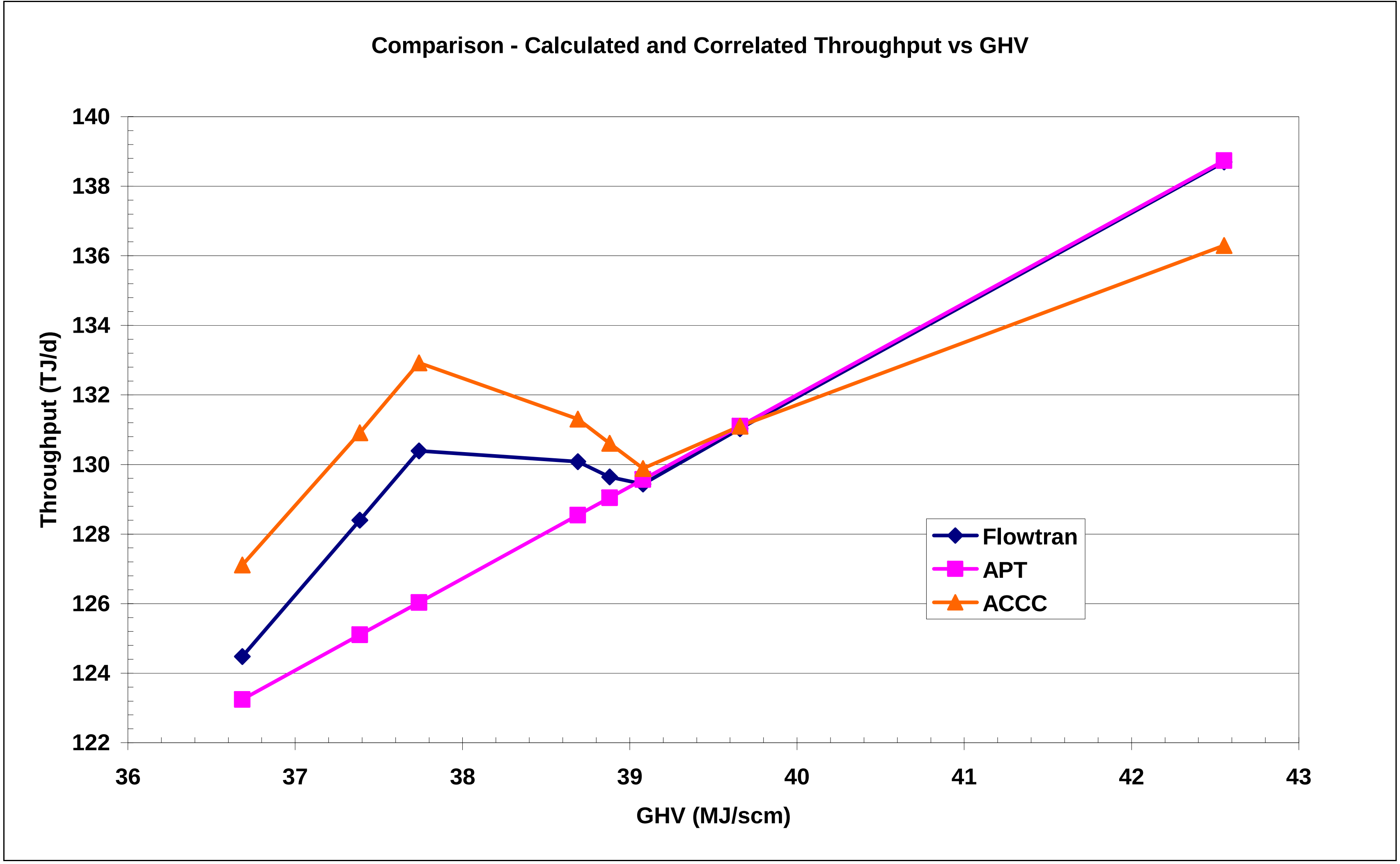

Figure 5 - Comparison - Calculated Pipeline Throughput vs Standard Specific Gravity