Matching Hydraulics Calculations: HYDPRO/MUDPRO+

Summary:
Though Pegasus Vertex, Inc. (PVI) constantly modifies and upgrades its software programs, fundamental calculations such as basic hydraulics do not change with time. There are some nuances involved and additional optional considerations that can be selected in the software programs. MUDPRO+ contains the same hydraulics calculations as HYDPRO, but HYDPRO, as a full drilling hydraulics and hole-cleaning model, has both additional calculation options and the potential for more detailed inputs.
When users of both MUDPRO+ and HYDRPO would like to compare results and ensure that the equivalent circulating density (ECD) and pump pressure (PP) values are similar, the input selections within the programs will need to be equivalent.

Software Versions:
MUDPRO+ version 4.0.1 or later; HYDPRO version 4.6.4 or later
To determine your software version, open the program and select Help > About. Release histories for the software can be viewed/discussed with the relevant PVI technical sales rep if desired.

Input Setup for Calculation Matching:
The mathematical model in HYDPRO and MUDPRO+ are the same. If the inputs, such as wellbore construction and mud property, are equal, the results should be equal as well. However, calculation interval/points and small rounding differences in the background of the calculation can occur.
PVI recommends calculations between; HYDPRO and MUDPRO+ with ECD and PP differences of ≤ 3 % or less than ± 0.3 ppg to be considered a match.

1) Survey Data
Input the MD, Inc, and Azi in the table; “Survey – Actual” in the MUDPRO+ Output window to the Survey Data table in HYDPRO. The MD, Inc, and Azi are from the General table in all the daily reports in MUDPRO+. If there is “-“ in the row, the MD, Inc, and Azi in this row should not be input into HYDPRO.

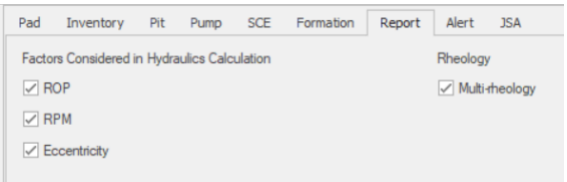
Survey - Actual

	Date	Rpt #	MD (ft)	TVD (ft)		Inc. (°)	Azi. (°)	Vsec (ft)	N+/S- (ft)	E+/W- (ft)	Dogleg (°/100ft)
				Input	Calculated						
1	11/05/18	1	1460.4	1460.4	1460.4	0.00	0	0.0	0.0	0.0	0.00
2	11/06/18	2	3692.0	3691.0		0.41	100.43	-	-	-	
3	11/07/18	3	3692.0	3691.0	3692.0	0.41	100.43	8.0	-1.4	7.9	0.02
4	11/08/18	4	3692.0	3691.0	3692.0	0.41	100.43	8.0	-1.4	7.9	0.02
5	11/09/18	5	6633.0	6607.0	6618.9	9.60	156.35	256.6	-228.5	116.8	0.32
6	11/10/18	6	8224.0	8184.0	8171.8	23.94	303.00	203.0	-172.7	-106.7	2.03
7	11/11/18	7	9890.0	8543.0	8979.0	94.00	295.00	1369.6	441.6	-1296.4	4.22
8	11/12/18	8	11528.0	8410.0	8874.9	93.28	299.00	2996.3	1183.6	-2752.6	0.25
9	11/13/18	9	13064.0	8320.0	8849.2	88.64	297.54	4527.8	1910.8	-4104.8	0.32
10	11/14/18	10	15046.0	8245.0	8829.5	92.50	297.00	6508.2	2818.7	-5866.1	0.20
11	11/15/18	11	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
12	11/16/18	12	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
13	11/17/18	13	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
14	11/18/18	14	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
15	11/19/18	15	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
16	11/20/18	16	15304.0	8232.0	8819.0	70.33	298.33	6765.8	2938.4	-6094.4	0.53
17	11/21/18	17	15304.0	8232.0	8819.0	92.16	298.33	6765.8	2938.4	-6094.4	0.53
18	04/21/22	18	19356.9	8232.0	8666.2	92.16	298.33	10813.2	4860.3	-9659.4	0.00
19	04/21/22	19	20669.3	8232.0	8527.5	99.99	298.33	12116.8	5479.1	-10807.2	0.60
20	05/04/22	20	20669.3	8232.0	8527.5	99.99	298.33	12116.8	5479.1	-10807.2	0.60
21	05/05/22	21	20669.3	8232.0	8527.5	99.99	298.33	12116.8	5479.1	-10807.2	0.60

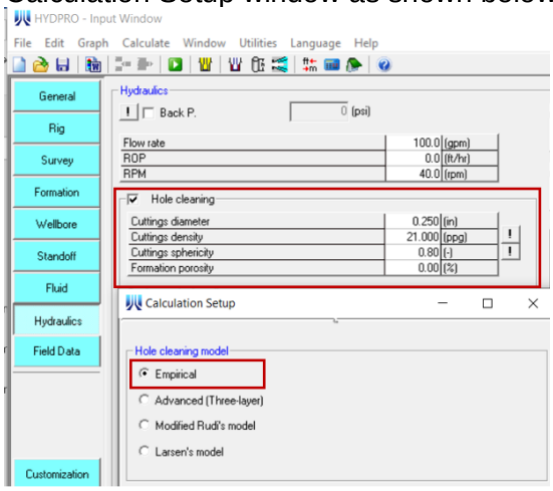
2) HYDPRO/MUDPRO+ Advanced Options (ROP, RPM, Eccentricity, Tool Joint Consideration)

MUDPRO+ has options for ROP, RPM, and Eccentricity considerations at the Pad level shown below. The ROP and RPM are input in the General table in a daily report. The tool joint OD and ID are input in the Drill String table.

For a simple comparison, it is recommended to check off all the options in MUDPRO+ and HYDPRO.



- ROP - Rate of Penetration: If it is checked, the program will calculate the cuttings fraction, slip velocity, travel ratio, and its effect on ECD.
  In HYDPRO, the ROP is input in the Hydraulics tab. The user needs to check “Hole cleaning” input the data below in the Hole cleaning table, and select “Empirical” as the Hole cleaning model in the Calculation Setup window as shown below.

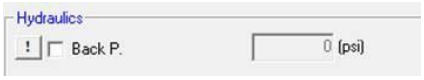


- RPM – Rotary Speed: Additional pressure loss inside the annulus will be calculated if the “RPM effect on hydraulics” is checked. The option “RPM effect on hydraulics” and RPM input in HYDPRO are located in the Hydraulics tab.
- Eccentricity: Tool joint OD and ID are required to be input in the daily mud report if the “Eccentricity effect on hydraulics” is checked. The program will calculate the eccentricity using hole ID, tool joint OD, and pipe OD. If the pipe is not centered in the well, the pressure loss inside the annulus will be reduced.
  The option “Eccentricity effect on hydraulics” in HYDPRO is also located in the Hydraulics tab. There are two options for pipe standoff input. One is “Calculate”, and the other one is “Input”. The user needs to select the first option “Calculate” to match the MUDPRO+ calculation.

MUDPRO+ does not account for the tool joint effect on hydraulics; the user needs to check off “Tool joint effect on hydraulics” when comparing the results from MUDPRO+ and HYDPRO.

3) Backpressure

MUDPRO+ does not consider back pressure, so it needs to be checked off in HYDPRO when comparing the ECD and pump pressure calculations. It is located in the Hydraulics tab.


Hydraulics
!
Back P.
0 (psi)