

A Dynamic Simulation Study: Dehydration Tanks TK-60A and TK-60B Inter-tank Level Balancing Lines

Summary: The effectiveness of the intended tank balance lines was investigated by performing simulations to determine the effect of upstream transients on the dehydration tank levels. A number of upset operating cases were simulated at both 17% and 35% WC and maximum tank level variations calculated. The results show that the current design is adequate when compared to operating with two extra hypothetical oil and water balance lines.

1. INTRODUCTION

As part of an Onshore Crude Processing Facilities Project, two new dehydration tanks (TK-60A and TK-60B) will be installed. Each tank has a capacity of 28,000 bbl and will be used to separate oil and water phases before further downstream processing. Two 24" booster pump suction lines (crude and water) are currently planned to be used for tank level balancing. A separate 6" emulsion balance line and 20" vapour balance line have also been provided.

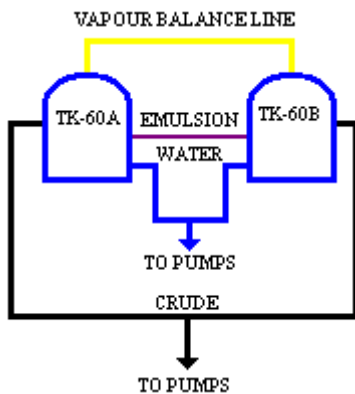


Fig 1. Dehydration Tank Balance Lines

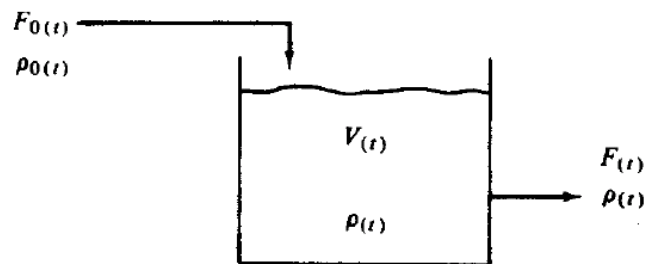
2. OBJECTIVE

The objective of this study is to determine the effectiveness and suitability of the current design under different dynamic operating scenarios. In particular, the variation in tank levels as a result of a lower offshore production rate (80,000 BPD) in one of the two separate process trains will be examined.

3. GENERAL TANK LEVEL EQUATIONS

Well established physical models for a typical gravity flow tank will form the basis for dynamic tank level modelling

purposes



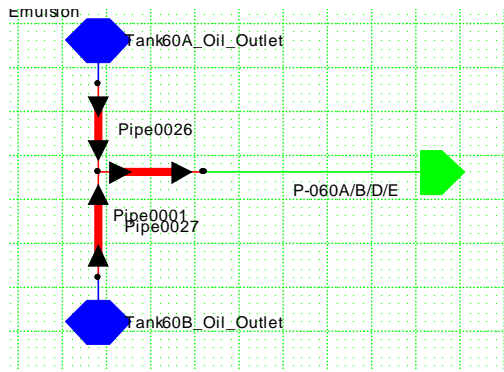
$$\frac{dv}{dt} = \frac{g}{L} h - \frac{K_F g_c}{\rho A_p} \quad (1)$$

$$A_t \frac{dh}{dt} = F_o - F \quad (2)$$

4. MODELLING ROUTE

Dynamic tank level modelling was carried out using the high fidelity hydraulic simulator – TLNET, which is a component of Energy Solutions' Pipeline Studio V 3.0. The following assumptions are made for the transient simulation:

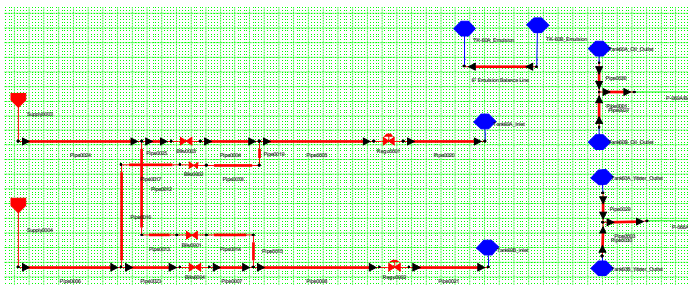
- Tank internal pressures are the same (i.e. The gas vapour balance line has not been modelled)
- Emulsion and water phases have not been modelled, instead only one oil phase is assumed to be present within the tank.
- Independent tank objects are not available within the TLNET simulation environment, however it is possible to model a tank by allocating one or more inlet and/or outlet nozzles to a predefined tank. Therefore, in order to simulate balancing lines, a number of outlet nozzles at different elevations are implemented. A representation of the oil balance line is shown below, a tank nozzle is depicted by a blue object, flow sinks (pumps, nozzles, etc) are shown as green objects.



- The same flowrate to the desalters is maintained at all times.
- A fixed simulation time-step of 0.05 seconds was used.
- No hydraulic verification has been performed on the inlet lines upstream of the dehydration tank, i.e. it is assumed that the dynamic flowrates are achievable.

5. SIMULATION ENVIRONMENT

The process flow scheme, as shown in the below figure, was configured to represent the dehydration tank crude inlet manifold. The two segregated production trains (A and B) with crossover line valves closed is the normal expected operating scenario. However, other scenario's, where the crossover valves are open, have also been simulated.



5.1 Case A – Offshore Flow Disruption-Failure of Emulsion Balance Line - 17% Water Cuts

At steady state conditions, the total offshore rate 365,000 BPD is equally split between two segregated process trains. At the start of the simulation the offshore rate to train A is cut to only 80,000 BPD, train B maintains 182,500 BPD. The initial tank level is 15m. Oil outlet nozzles have been set at 13m, and water outlet nozzles at 3m. The total dynamic simulation run time is one hour and twenty minutes under these condition. The results presented below do not include the use of the 6” emulsion balance line.

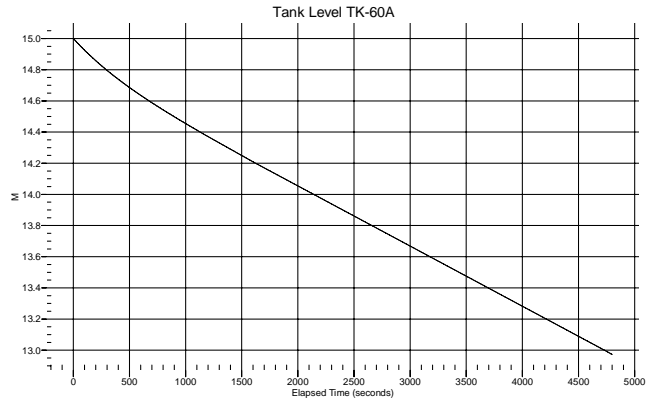


Fig. 2. Case A: TK-60A dynamic level variation

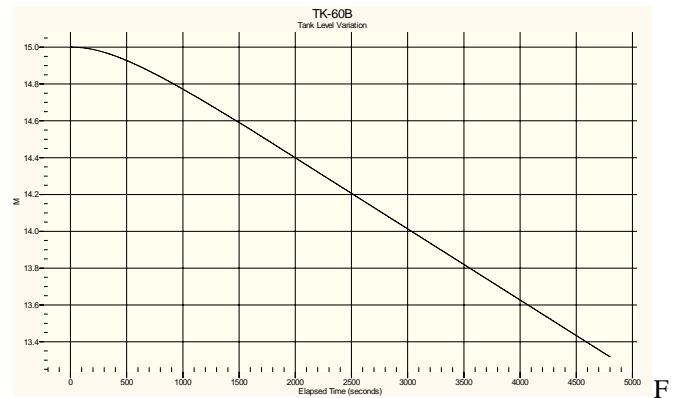


Fig. 3. Case A: TK-60B dynamic level variation

Under these conditions, the maximum difference in level is approximately 0.4m. Further tank level equalisation could be achieved, by opening one of the crossover line valves and reducing the set-point of one of the PCV's.

5.2 Case B – Offshore Flow Disruption- Emulsion Balance Line Operational-17% Water Cut

This scenario follows the same operational pattern and dynamic disruption as case A, however it is assumed that the 6” emulsion balance line is now in operation.

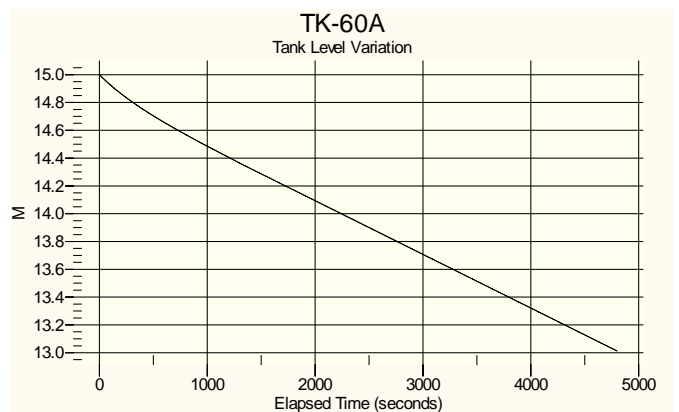


Fig. 4. Case A: TK-60A dynamic level variation

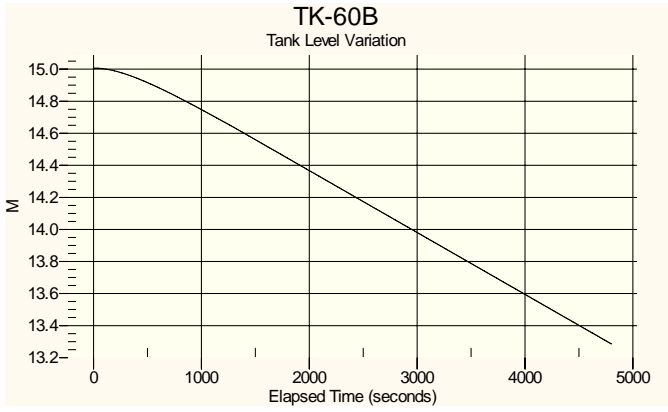


Fig. 5. Case B: TK-60B dynamic level variation

In this case it is observed that the maximum difference in level is 0.3m. The expected flow rate through the 6" line is approximately 80 m³/h.

5.3 Case C – Offshore Flow Disruption- Two Additional Balance Lines - 17% WC

This case follows the same operational scenario as A and B. Two additional 24" balance lines have been provided at 12m and 1m.

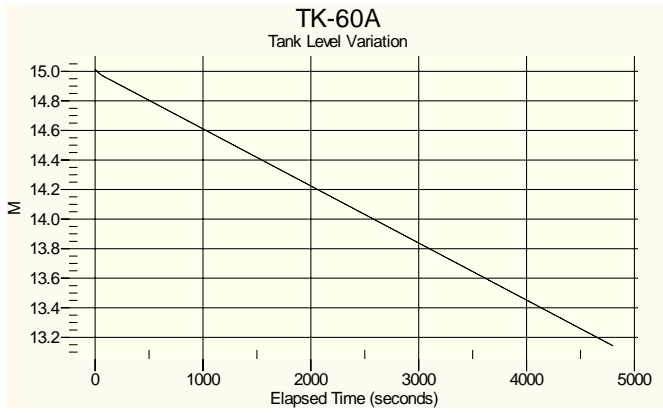


Fig. 6. Case C: TK-60A dynamic level variation

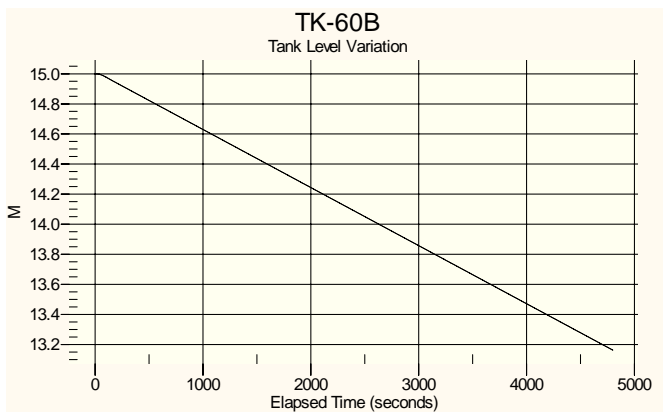


Fig. 7. Case C: TK-60B dynamic level variation

5.4 Case D – Train A to Train B Crossover Valve Open - 17% WC

During steady state conditions, the two production trains are running with equal flowrates to both dehydration tanks. Both of the crossover valves are closed and tank levels are equal at 15m. The transient scenario maintains the full offshore rate (365,000 BPD), however 80,000 BPD is sent to train A whilst train B receives the remaining 285,000 BPD. This is simulated by fully opening one of the cross over valves (as would be the case with an MOV) and throttling the PCV upstream of dehydration tank A so that only 80,000 BPD is allowed the pass through the valve.

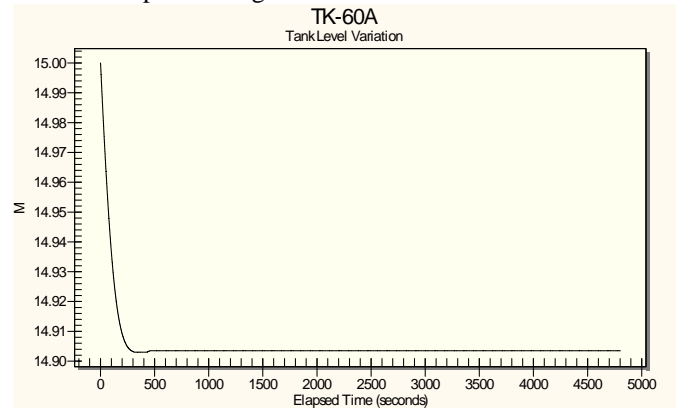


Fig. 7. Case D: TK-60A dynamic level variation

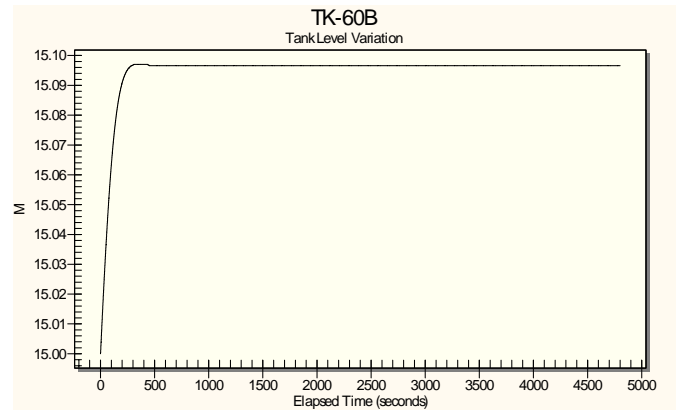


Fig. 8. Case D: TK-60B dynamic level variation

5.4 Case E – Train A to Train B Crossover Valve Open – Additional Balance Lines -17% Water Cut

The assumed scenario is the same as Case D, however two additional balance lines at 12m and 1m have been included. The results are shown below:

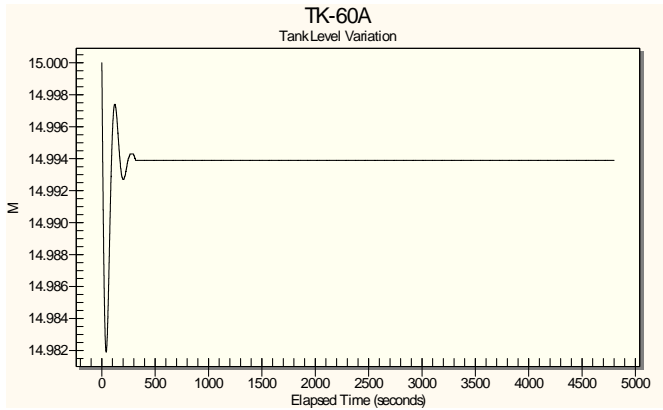


Fig. 9. Case E: TK-60A dynamic level variation

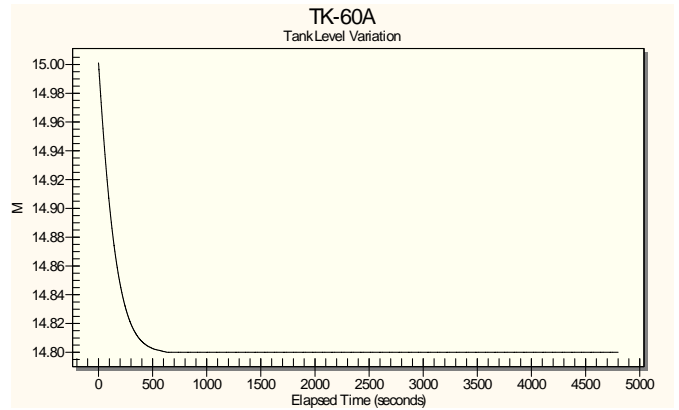


Fig. 11. Case F: TK-60A dynamic level variation

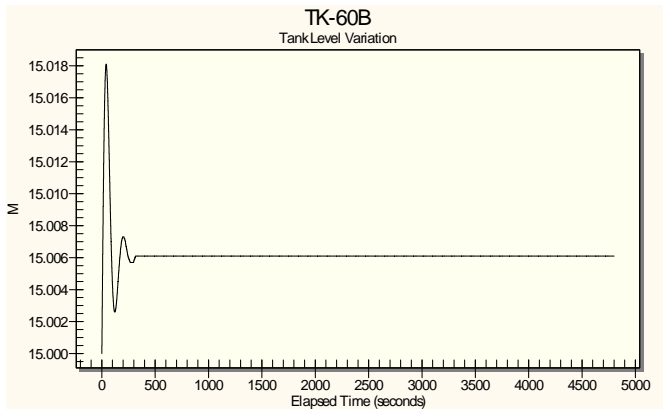


Fig. 10. Case E: TK-60B dynamic level variation

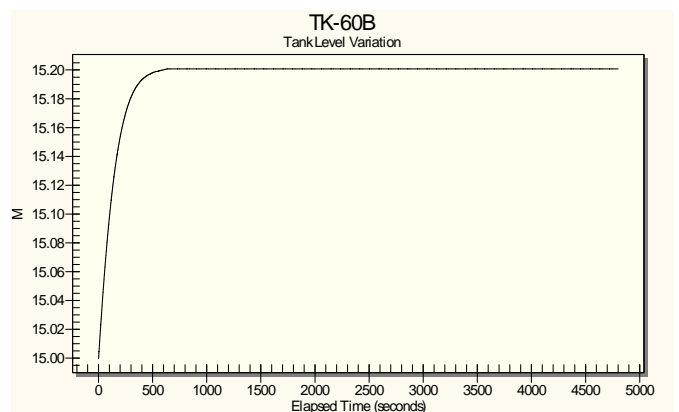


Fig. 12. Case F: TK-60B dynamic level variation

Tank levels equalize rapidly within 500 seconds with a slight and insignificant offset.

5.5 Case F – Train A to Train B Crossover Valve Open – 35% Water Cut

This simulation scenario is based on 35% water cut or a total offshore rate of approximately 467,000 BPD. It is expected that this case represents the worst case conditions in terms of tank level unbalancing. During transient conditions, dehydration tank A receives 80,000 BPD, whilst tank B receives 387,000 BPD. The flow re-routing is carried out in by opening only one MOV and throttling the PCV on the inlet of dehydration tank A.

As can be seen from the simulation results, the maximum difference in tank level is 0.4m whilst operating under these conditions. The dynamic simulation results show that the level-flow cascade controller averaging these two levels should still send the same signal to the existing flow controllers thus allowing the desalter rate to be maintained.

5.6 Case G – Train A to Train B Crossover Valve Open – Additional Balance Lines -35% Water Cut

The final case, simulates two 24” hypothetical balance lines at 12m and 1m. The implemented dynamic disruption is the same as case F.

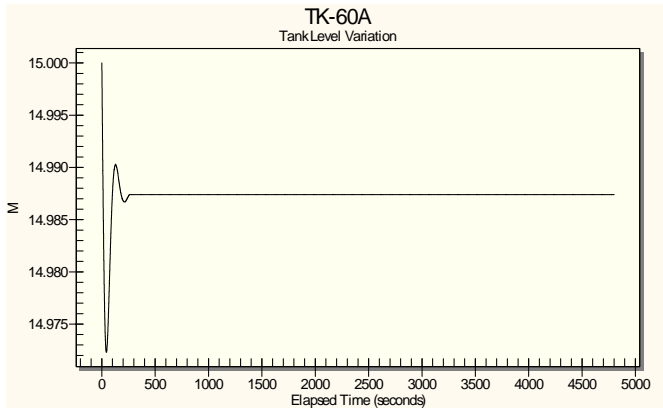


Fig. 13. Case G: TK-60A dynamic level variation

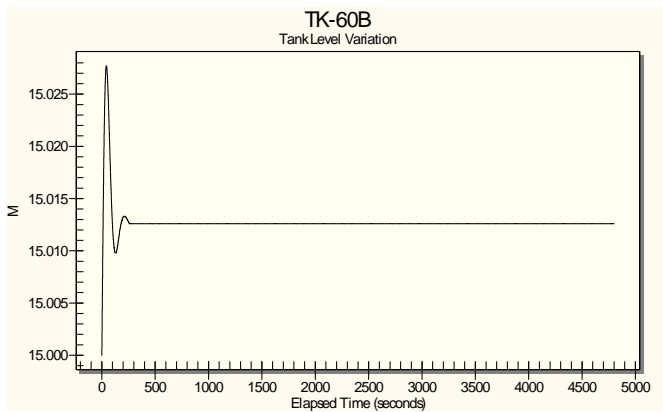


Fig. 14. Case G: TK-60B dynamic level variation

6. CONCLUSIONS

The simulation results demonstrate that under certain and non-frequent operating conditions a maximum tank level imbalance of 0.4m may occur. The introduction of two extra 24" balance lines (intended for the oil and water phases) can improve the situation. However, since the tank level difference is not considered to be significant under the worst case conditions, further consideration of additional lines or a flow inlet balancing system is not required.