


# Intelligent Digital Oilfield Management Systems

# User's Guide

v.2.02

**Developed by:**

**The University of Texas at Austin**

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# Introduction

Welcome to iDOMS! iDOMS is a software application developed by the University of Texas at Austin that assists operators in properly selecting choke sizes or ESP Frequencies in existing oilfields. Using state of the art software architecture, iDOMS effectively integrates models for reservoir, wellbore and surfaces facilities into an intuitive, user-friendly interface.

The purpose of this User's Manual is to guide the user through iDOMS installation, briefly present iDOMS capabilities and describe the process of providing the input parameters to the model.

# iDOMS Licensing

New users may obtain a 60-day trial license by registering at the following link:

http://tinyurl.com/iDOMS-Registration

Following registration, our team will provide you with the iDOMS installation package.

# Requirements and Installation

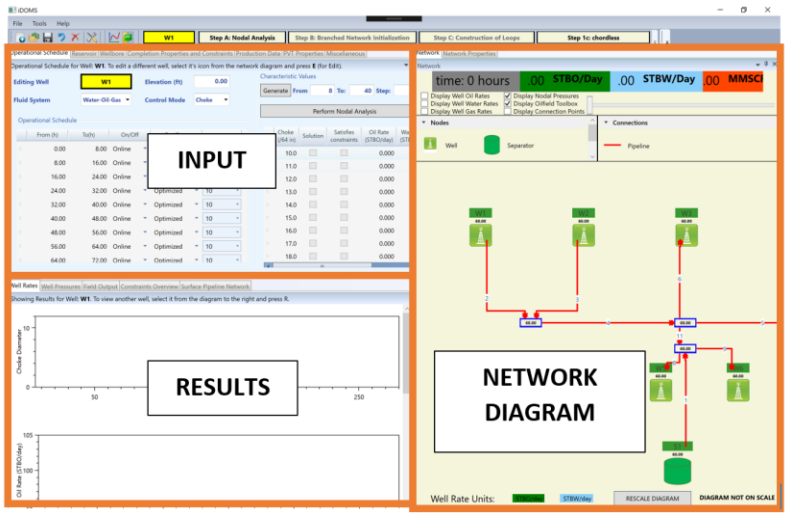
iDOMS Requirements:

- Windows 7 or later
- .NET Framework 4.5 or later

To install iDOMS, please run the iDOMSInstaller.exe provided to you by our developer team.

# The iDOMS interface

The iDOMS interface consists of three primary sections as shown in the image below:



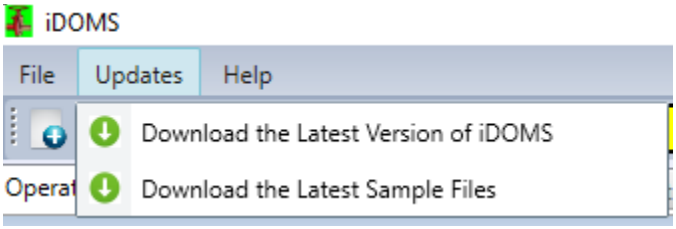

INPUT Section:
Used for editing Reservoir, Wellbore and completion properties for each well present in the field

RESULTS Section:
Provides the rates produced from each well as well as the total field production as a function of time

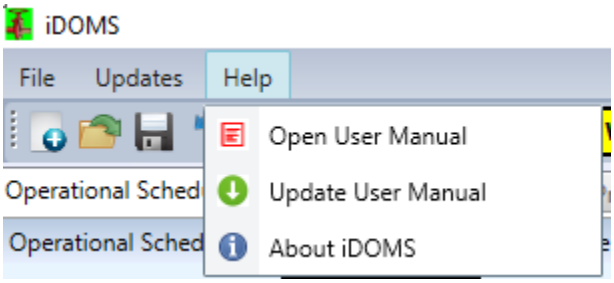
NETWORK DIAGRAM Section:
Drag & Drop construction of the surface network and monitoring of nodal pressures as a function of time

# Updates

The user may download the latest version of the executable as well as Sample files from the Update Menu:




Additionally, the user can also download the latest version of the User's Manual from the Help Menu:




# The Network Diagram

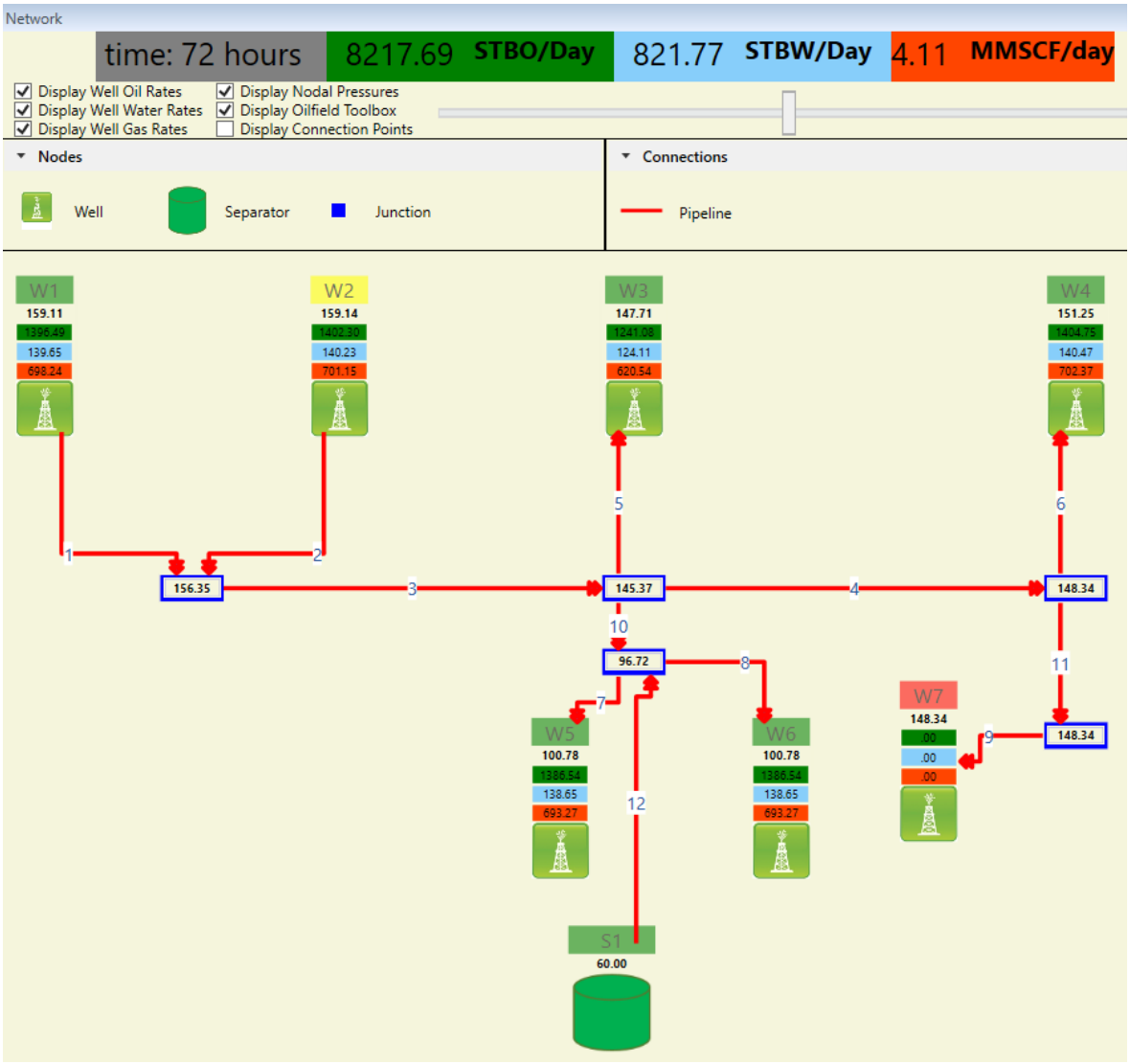
## Network Components

The following table illustrates the network components available in the current version of iDOMS:

| *Icon* | *Description* | *Comment* |
|---|---|---|
|  | Well | Consists of the reservoir, wellbore and completion entities |
|  | Junction | Used to connect two or more pipelines. For each junction, iDOMS calculates the corresponding nodal pressure |
|  | Separator | Represents an outlet of constant pressure. Only one separator is allowed in the system |
|  | Surface Pipeline | A pipeline connecting two of the previously mentioned notes. iDOMS calculates the flow-rate and the pressure drop for each pipeline in the surface network |

## Network Visualization & Notations

The Network Dashboard provides an overview of the surface pressures, the individual well rates and the total field production.




### Notations

| Notation | Well Status |
|---|---|
| Well Name | Online & Optimized |
| Well Name | Online & Specified (fixed choke size or ESP Freq) |
| Well Name | Offline |

| Notation | Units |
|---|---|
| Well Name | |
| **Well Head Pressure** | psi |
| Oil Rate | STBO/day |
| Water Rate | STBW/day |
| Gas Rate | MScf/day |

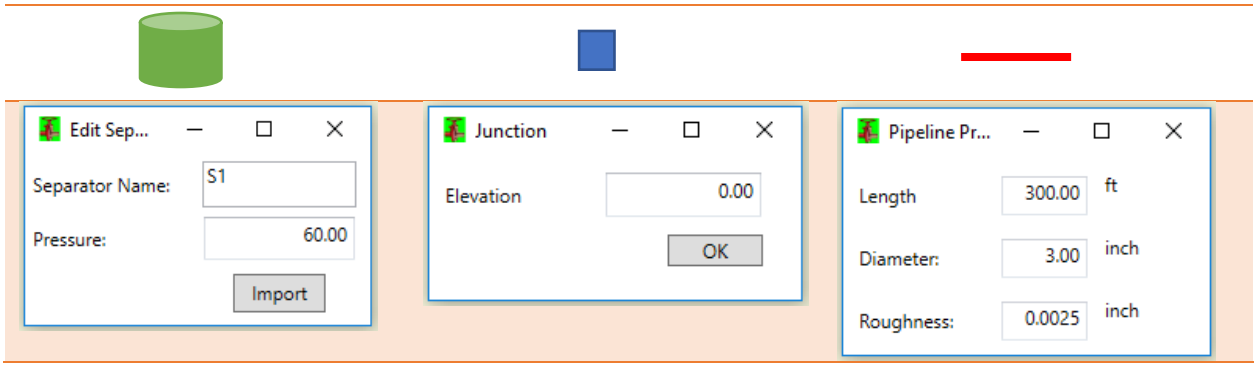
## Adding Network Elements

To add a network element to the network, simply drag & drop it from the diagram toolbox into the surface network.

## Editing Network Elements (Junctions, Pipelines or Separator)

**To edit the properties of a network element, select that particular item on the network diagram and press the E button on the keyboard (E stands for Edit).**

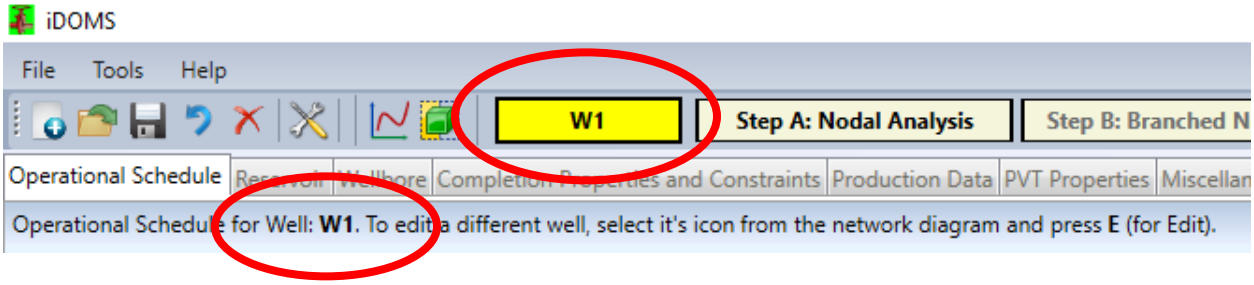
For the case of junctions, separators or surface pipelines, a window will pop-up that will enable the user to edit the properties of that particular element. The following table presents the edit window that pops-up upon pressing the "E" button.




## Editing Network Elements (Wells)

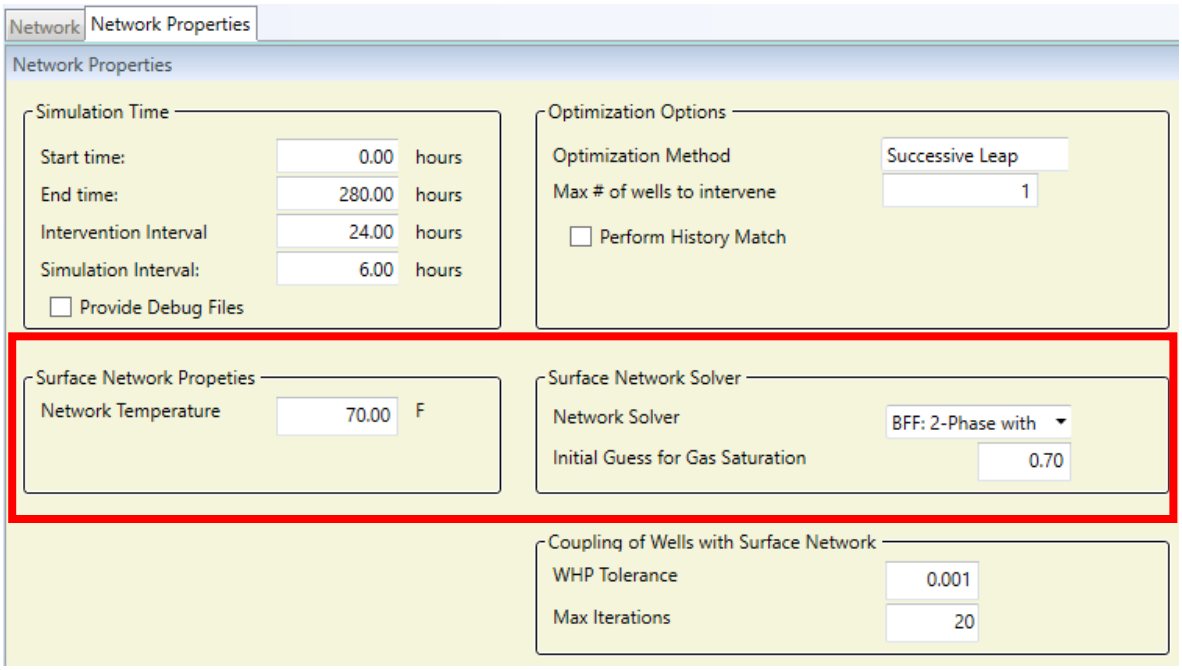
**To edit the properties of a well, select that particular well on the network diagram and press the E button on the keyboard (E stands for Edit).**

Upon pressing E, the user is now able to edit the reservoir, wellbore, completion and PVT properties for that particular well. The well that is currently being edited is shown in the yellow box at the toolbar:




## Properties of the Surface Flowline Network

The user may edit the surface flowline network properties by chancing the values unde the "Network Properties Tab".




## Coupling of wells with the surface network

The user may adjust the WHP tolerance. The global error at the wellhead pressures is calculated as:

$$\frac{1}{\mathrm{N}}\sum_{i}\frac{\left|WHP_{welli}^{k+1}-WHP_{welli}^{k}\right|}{WHP_{welli}^{k}}$$ , where

N is the number of wells in the system, i the well index and k the iteration index.

# Managing Wells

## Adding a new well

To add a new well, simply drag & drop the well icon from the oilfield toolbox into the network diagram. The user will then be asked if he wants to inherit the well properties from a well that already exists in the field

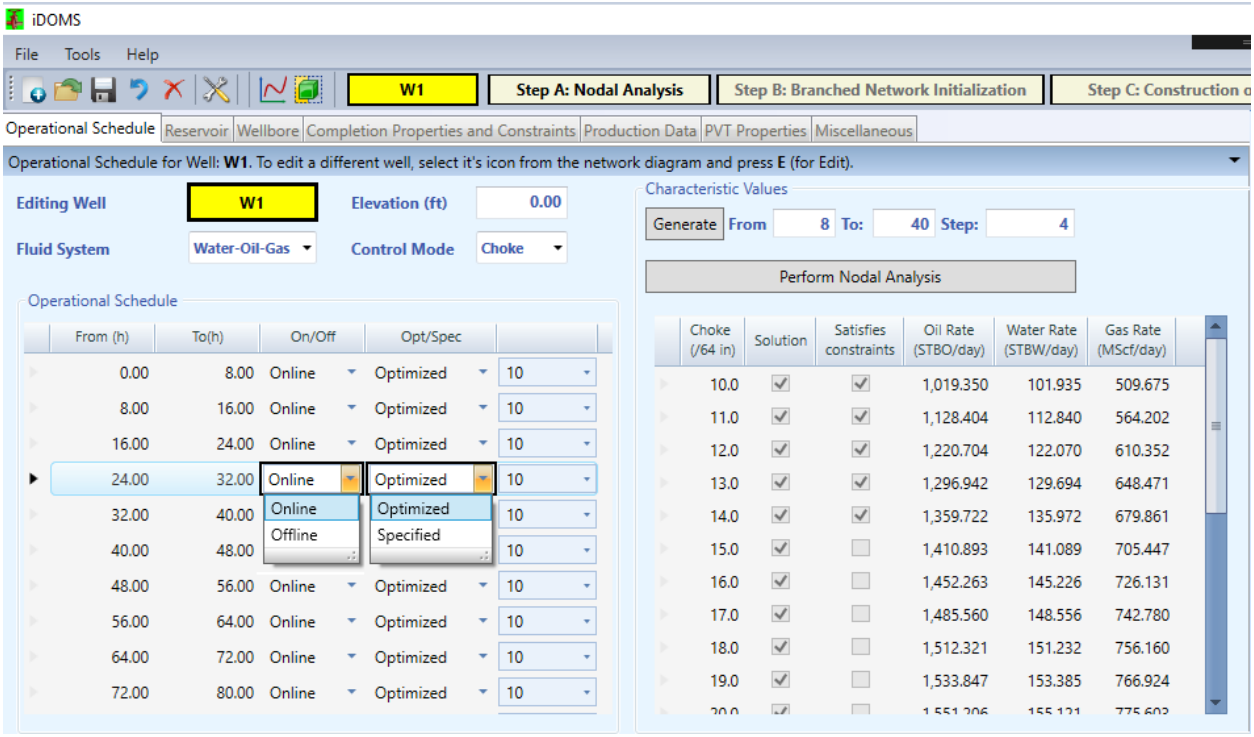
## Selecting a well to edit Reservoir, Wellbore or Completion Properties

**To edit the properties of a well, select that particular well on the network diagram and press the E button on the keyboard (E stands for Edit).**

Upon pressing E, the user is now able to edit the reservoir, wellbore, completion and PVT properties for that particular well. The well that is currently being edited is shown in the yellow box at the toolbar

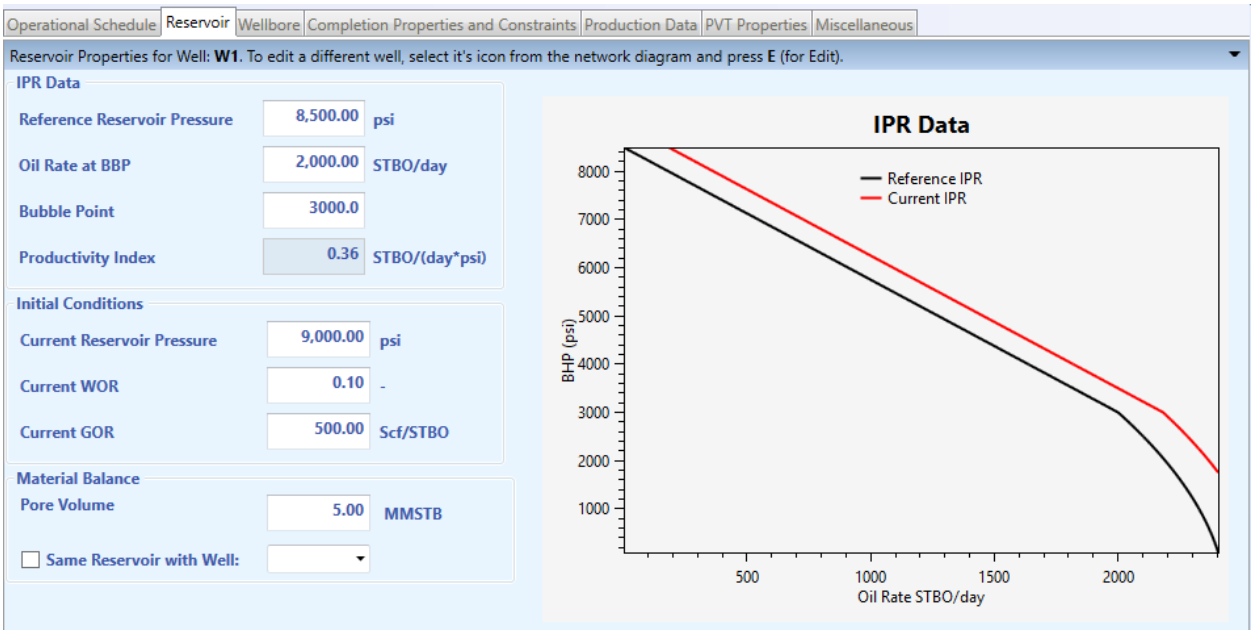
## Operational Schedule

In this section we can determine if the well is flowing naturally (in which case the control mode is set to "Choke") or produced with an ESP (control mode set to "ESP"). Additionally, the user may also provide, for various time intervals the well status (i.e. online/offline) or whether is produced at a fixed choke size ("Specified Mode") or optimized choke size ("Optimized") or ESP frequency. The user may also provide a list of available choke sizes. The available choke sized may also be automatically generated using the "Generate" button.



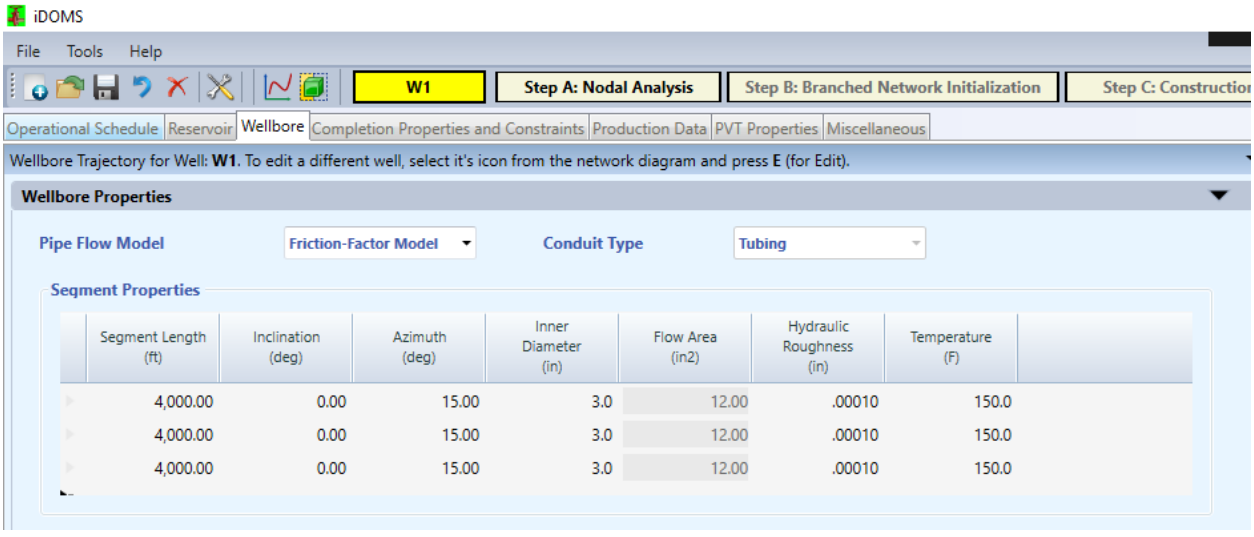
## Reservoir properties

In this Section the user provides the IPR curve as well as the bubble-point-pressure which determines the end of the linear portion of the IPR. The model used to Generate the IPR is Vogel's Equation.



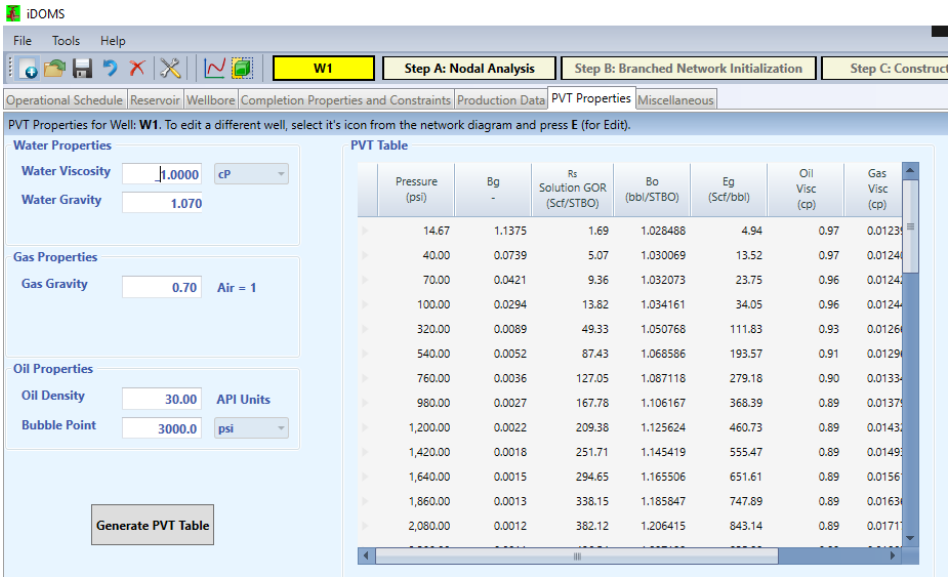

## Wellbore Trajectory

In this tab, the user provides the geometry for each segment of the wellbore (diameter, length, roughness). The topmost record of the table represents the wellbore segment closest to the wellhead.



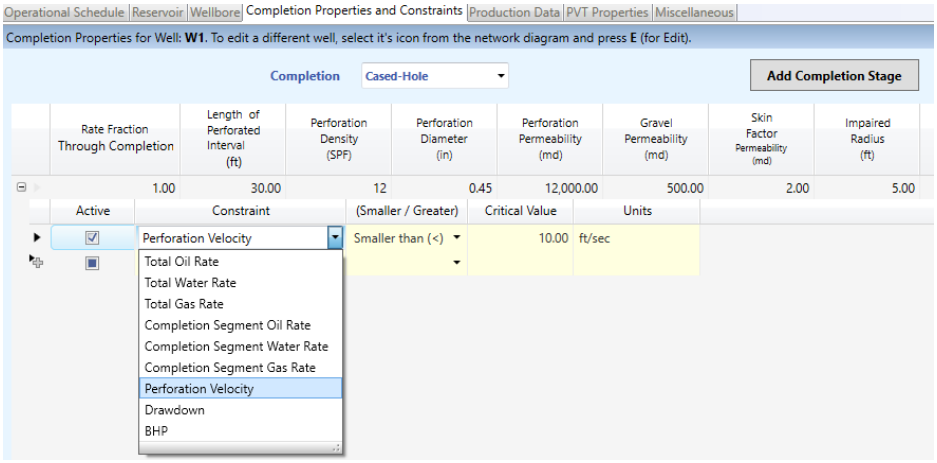
## PVT Properties

In this tab the user may edit the properties of the reservoir fluids. The reservoir temperature is considered equal to the temperature of the bottommost wellbore segment. The PVT table may be automatically generated based on correlations or manually edited by the user. Finally, these PVT properties are utilized for calculating the pressure drop along the wellbore and performing the material balance calculations.




## Completion Properties & Production Constraints

In this tab the user provides the completion properties as well as the completion constraints for the well shown in the yellow box. The completion properties and constraints depend on the selected completion type. The constraint might be set to be smaller or larger than the critical value provided by the user. It is important to note that the "Rate Fraction through Completion Interval" represents the fraction of the total well rate that is being produced from that particular completion segment. Consequently, for any well, the sum of all Rate fractions should equal to one.



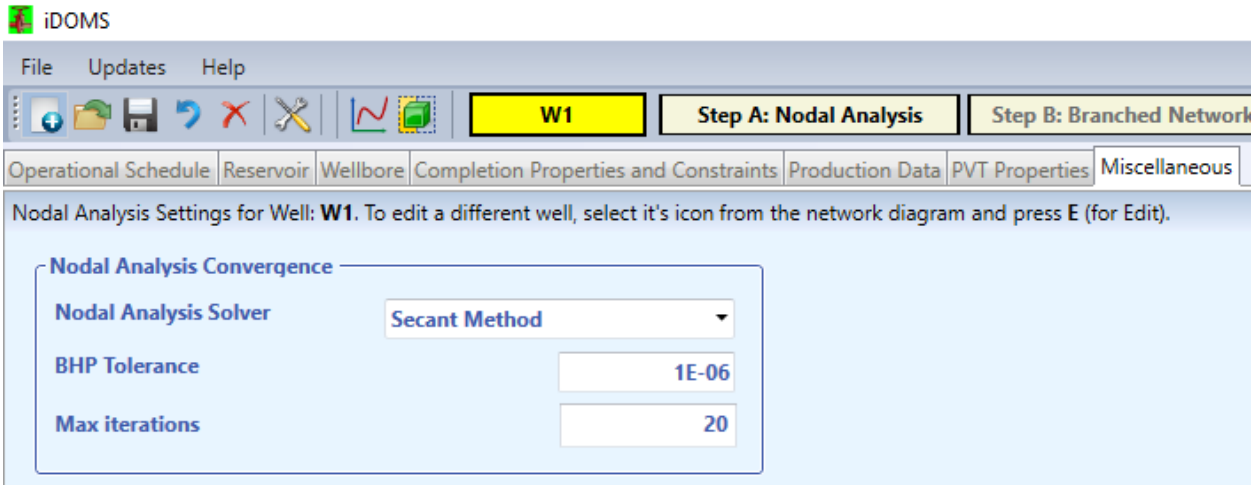
# Numerical Preferences

## Nodal Analysis

In this section the user may edit the Nodal Analysis convergence criteria for the well shown in the yellow box. The Secant method is the recommended convergence method. The BHP error is defined as:

$$BHP_t = \frac{\left| BH\,\mathrm{P}_{res} - BHP_{wellbore} \right|}{BHP_{res}}$$

To ensure an accuracy of 0.01 in the calculation of the BHP and assuming a BHP of 5000psi, the tolerance should be set to 1.0E-6.



# Simulation Steps

## Step A: Nodal Analysis

In this Step, iDOMS performs the nodal analysis for all well in the field. If for the given well, flow is not possible, iDOMS will display a message to the user. In this case the user will have to change the control mode from “Choke” to “ESP”, relax the completion constraints or change the reservoir or wellbore properties.

## Step B: Instantiation of the Branched Network

In this Step iDOMS will couple the wells with the surface network using the smallest compatible choke sizes or ESP frequencies. iDOMS will calculate the surface pressures as well as the oil, water and gas production for each well.

If Convergence is not achieved, the user may alter the initial guesses by manually changing the value of the surface pressures (values under flashing well names) and/or the pipeline fluid velocities by selecting a pipeline and pressing E (for “Edit”).

## Step C: Construction of Loops

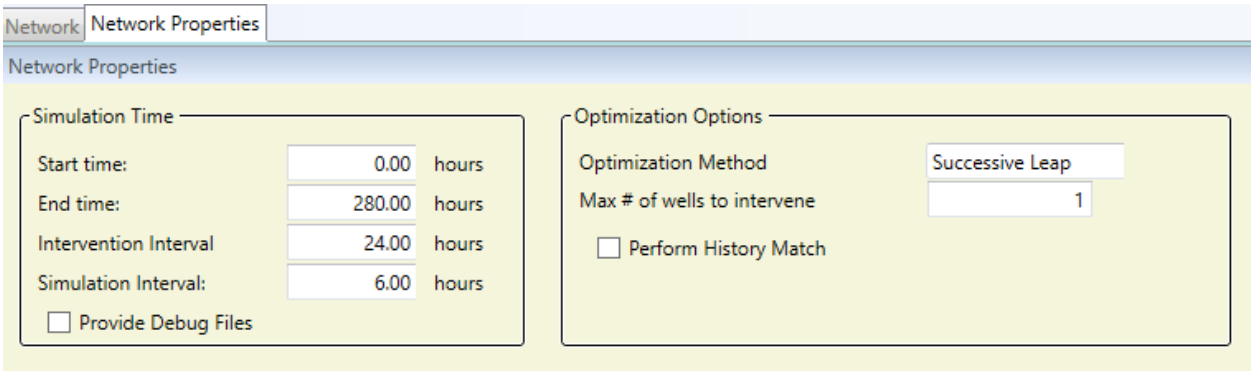
In this step the user may construct loops, if any.

To add a loop to the network, the user should follow the following procedure:

a) Add one or more pipelines that close a loop
b) Set the gas saturation of this pipelines equal to the saturation of adjacent pipelines. (You may set these values by selecting a pipeline and then pressing E);
c) Set the liquid and gas velocities (U1vel and U2vel) equal to the velocities of the adjacent pipelines
d) Click on “Step C: Construction of Loops”
e) If Convergence is achieved procced with the next loop or process with iDOMS Optimization / Simulation

## iDOMS Simulation

This step requires that Steps A, B and C have previously been run.




### Simulation Times

With regard to simulation time, the following should be mentioned:

- "Intervention Interval": This is the frequency that the optimization algorithm will search for possible adjustment on choke sizes or ESP frequencies on wells that are set on "Optimized Mode". For example, if we are willing to change choke sizes every 12 hours, this value should be set to 12.

- "Simulation Interval": This is the frequency that the production rates and pressures are updated under constant choke sizes or ESP frequencies in order to capture the effect of depletion. The "Simulation Interval" should be smaller that the "Intervention Interval"

### Optimization Methods

iDOMS currently supports two optimization methods:

a) **Extensive Search with Single Well Intervention**
   This method identifies the single well, the intervention on which will yield the highest incremental increase in the total field production

b) **Successive Leap**
   In this method the user provides the maximum number of wells that intervention is desired. For example in a field of 10 wells, an operator may wish to adjust choke sizes on up to 3 wells every 12 hours. In this case, the **max # of wells to intervene** should be set equal to three (3) and the **Intervention Interval** equal to 12. The algorithm will then identity choke adjustments for up to three wells, and these adjustments are expected to provide the maximum daily field production.

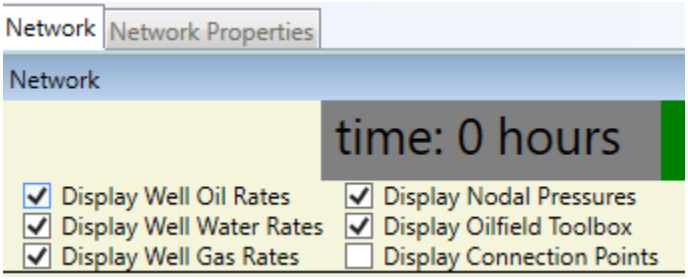
Additional optimization methods, including MINLP, gradient free optimization techniques and stochastic optimization are currently being implemented and will be available in future versions of iDOMS.

## Simulation of Surface Network for user specified well rates

This option enables the user to obtain the solution of the surface network (surface pressures and liquid rates through each pipeline of the network) for user-specified production rates.

To provide the desired liquid influxes, the user should:

a) Enable the display of Oil, Water and Gas rates




b) Manually Provide the influx rates for each well

| | | |
|---|---|---|
|  | Oil Rate in STBO/day | 2000.00 |
| | Water Rate in STBW/day | 1800.00 |
| | Gas Rate in MScf/day | 980.00 |



**c)** Execute **"Simulation of Surface Network"**

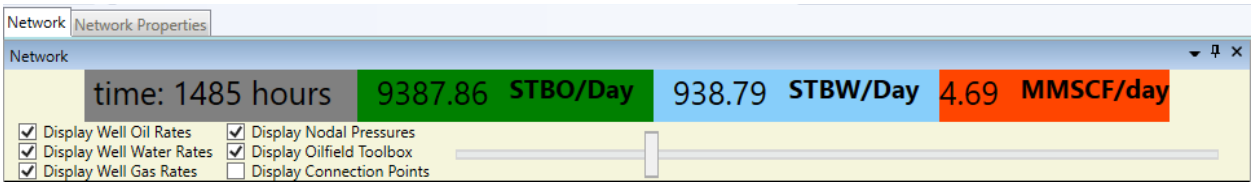
If Convergence is not achieved, the user may manually adjust the surface pressures and /or the pipeline fluid velocities from the surface network diagram.

# Output

## Field Results

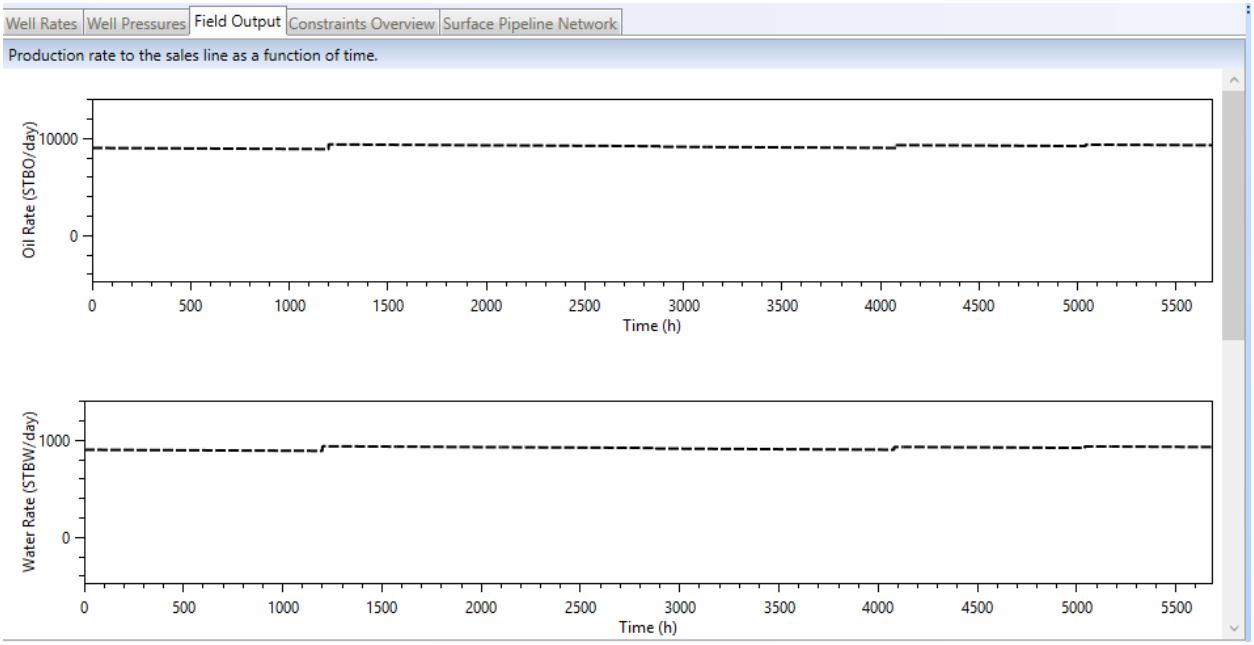
### Output as a function of time

Upon execution of iDOMS Simulation/ Optimization, the user can view the network results at a specific snapshot in time by adjusting the **time slider** on top of the network diagram. The rates on top of the diagram provide the total field production for that time




### Field Production versus time

To view the field liquid and gas production rates, select the field output at the results section



### Monitoring of the Surface flowline System

To view the solution of the surface flowline network (i.e. flowrates and pressure drops along each pipeline, select the Surface Flowline Network at the Resutls Section

Well Rates | Well Pressures | Field Output | Constraints Overview | Surface Pipeline Network

Pipeline Rates and Pressure Drops for each Pipeline in the Surface network. Time is: **1140hours.**
To view results for a different timeframe, slide the time bad on top of the network diagram.

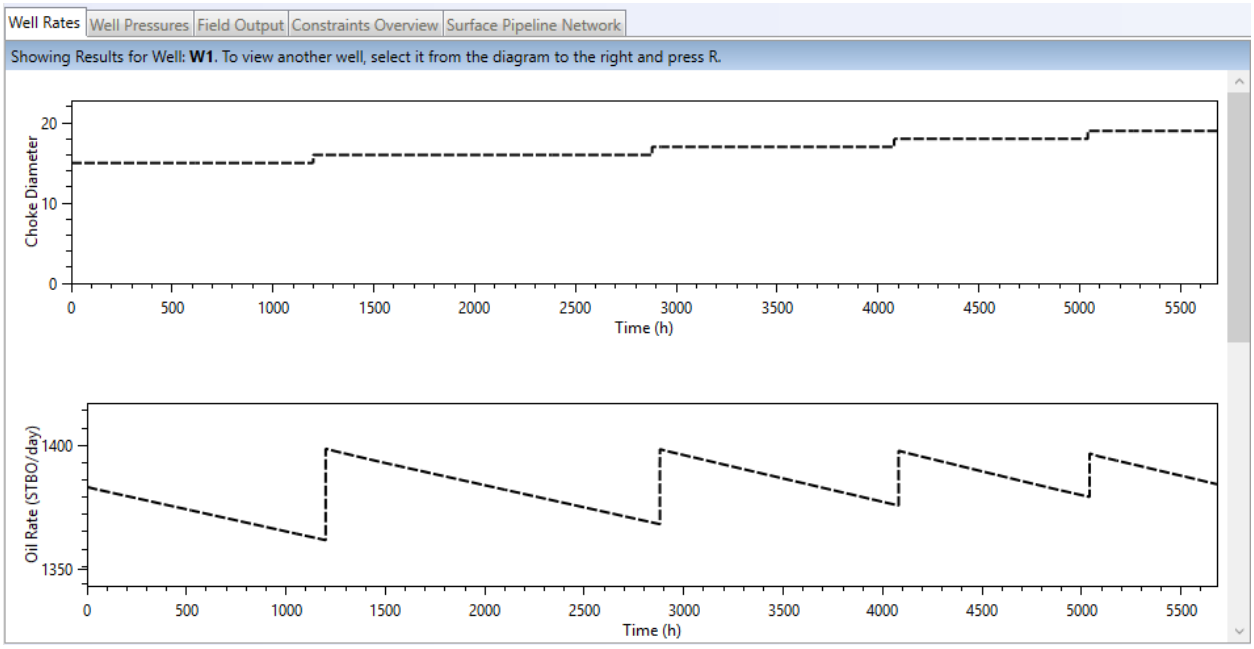
| Pipeline ID | Length (ft) | Pstart (psi) | Pend (psi) | DP (psi) | Oil Rate (STBO/day) | Water Rate (STBW/day) | Gas Rate (Scf/day) | Liq Den (kg/m3) | Gas Den (kg/m3) | Oil Vel (m/s) | Gas Vel (m/s) | Gas Sat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 300.00 | 173.33 | 171.26 | 2.07 | 1,249.10 | 124.91 | 624,549.09 | 885.00 | 15.08 | 0.52 | 2.31 | 0.82 |
| 2 | 300.00 | 173.39 | 171.26 | 2.13 | 1,266.85 | 126.68 | 633,423.18 | 885.00 | 15.08 | 0.52 | 2.34 | 0.82 |
| 3 | 300.00 | 171.26 | 163.07 | 8.19 | 2,515.94 | 251.59 | 1,257,972.27 | 885.00 | 14.60 | 1.04 | 4.81 | 0.82 |
| 4 | 300.00 | 163.07 | 171.97 | -8.90 | -2,629.36 | -262.94 | -1,314,679.42 | 885.00 | 14.63 | -1.08 | -5.01 | 0.82 |
| 5 | 300.00 | 163.07 | 165.18 | -2.11 | -1,233.90 | -123.39 | -616,949.69 | 885.00 | 14.31 | -0.51 | -2.40 | 0.83 |
| 6 | 300.00 | 171.97 | 174.10 | -2.12 | -1,266.70 | -126.67 | -633,348.29 | 885.00 | 15.15 | -0.52 | -2.33 | 0.82 |
| 7 | 300.00 | 101.94 | 105.28 | -3.34 | -1,281.24 | -128.12 | -640,619.93 | 885.00 | 8.80 | -0.53 | -4.06 | 0.88 |
| 8 | 300.00 | 101.94 | 105.28 | -3.34 | -1,281.24 | -128.12 | -640,619.92 | 885.00 | 8.80 | -0.53 | -4.06 | 0.88 |
| 9 | 300.00 | 174.41 | 176.82 | -2.41 | -1,362.66 | -136.27 | -681,331.13 | 885.00 | 15.40 | -0.56 | -2.47 | 0.81 |
| 10 | 300.00 | 163.07 | 101.94 | 61.14 | 6,379.20 | 637.92 | 3,189,601.38 | 885.00 | 11.61 | 2.63 | 15.33 | 0.85 |
| 11 | 300.00 | 171.97 | 174.41 | -2.44 | -1,362.66 | -136.27 | -681,331.13 | 885.00 | 15.17 | -0.56 | -2.51 | 0.82 |
| 12 | 300.00 | 60.00 | 101.94 | -41.94 | -8,941.68 | -894.17 | -4,470,841.24 | 885.00 | 6.97 | -2.07 | -20.12 | 0.91 |

## Individual Well Results

To view the results of a Well, select that particular from the network diagram and press R (for Results)

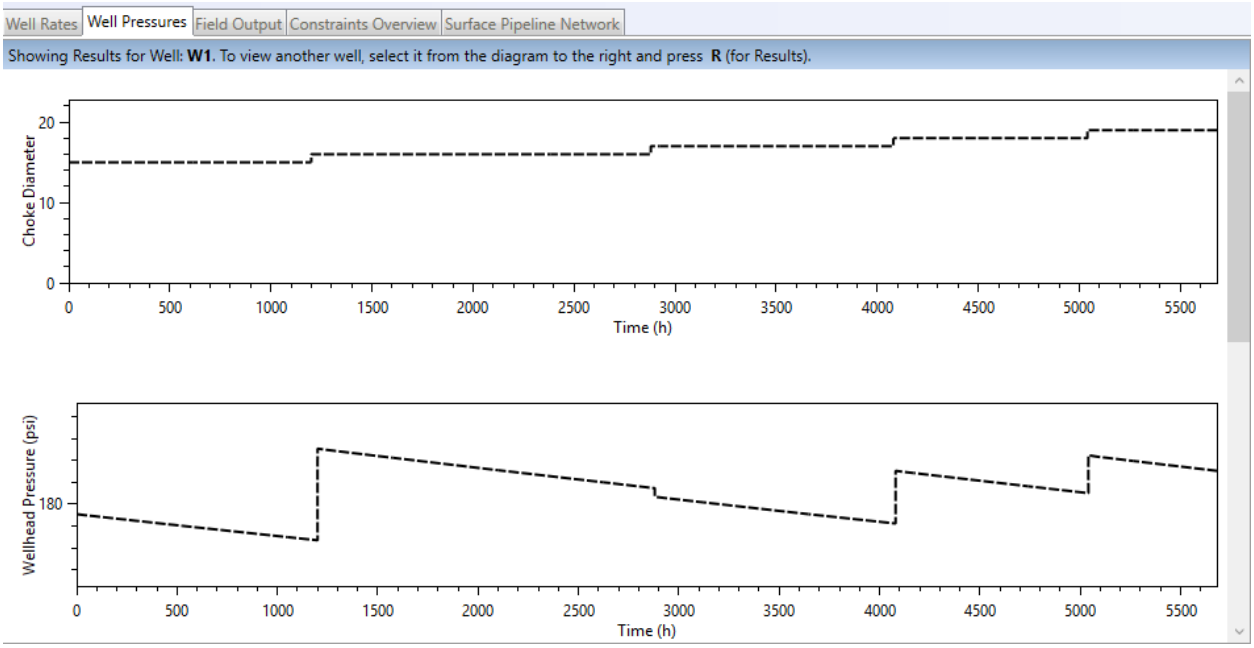
### Well rates

The user may view the liquid and gas rates of the selected well by selecting the Well Rates tab from the Results Section.



## Well Pressures

The user may view the Surface Pressure (downstream of the choke), the BHP and the average reservoir pressure by selecting the Well Pressures tab from the Results Section.




## Constraints overview

To view the actual values of the provided constraints in comparison to the critical values (maximum or minimum) the user may select the Constraints Overview tab from the results section. Select the constraint you would like to view by navigating through the Tres structure on the left.

