Final Commissioning and Start - Up

The key is to develop effective plans and procedures that incorporate the reservoir all the way through the export lines. During the procedure writing effort, design errors and omissions are frequently discovered. Unfortunately, the operating procedures are often written after the design is complete, sometimes after construction is complete. It is often too late to fix these problems and the procedures must be adjusted to accommodate the inadequate design.

Procedures should be written in stages. The first procedures should be high level, and subsequently gradually matured along with the design. Processes should be designed to be operated; operation shouldn't be an afterthought. GATE engineers have extensive experience in writing commissioning, initial startup and operating guidelines and procedures.

The initial startup of a production system is one of the most challenging periods in field life. Many issues complicate this event including:

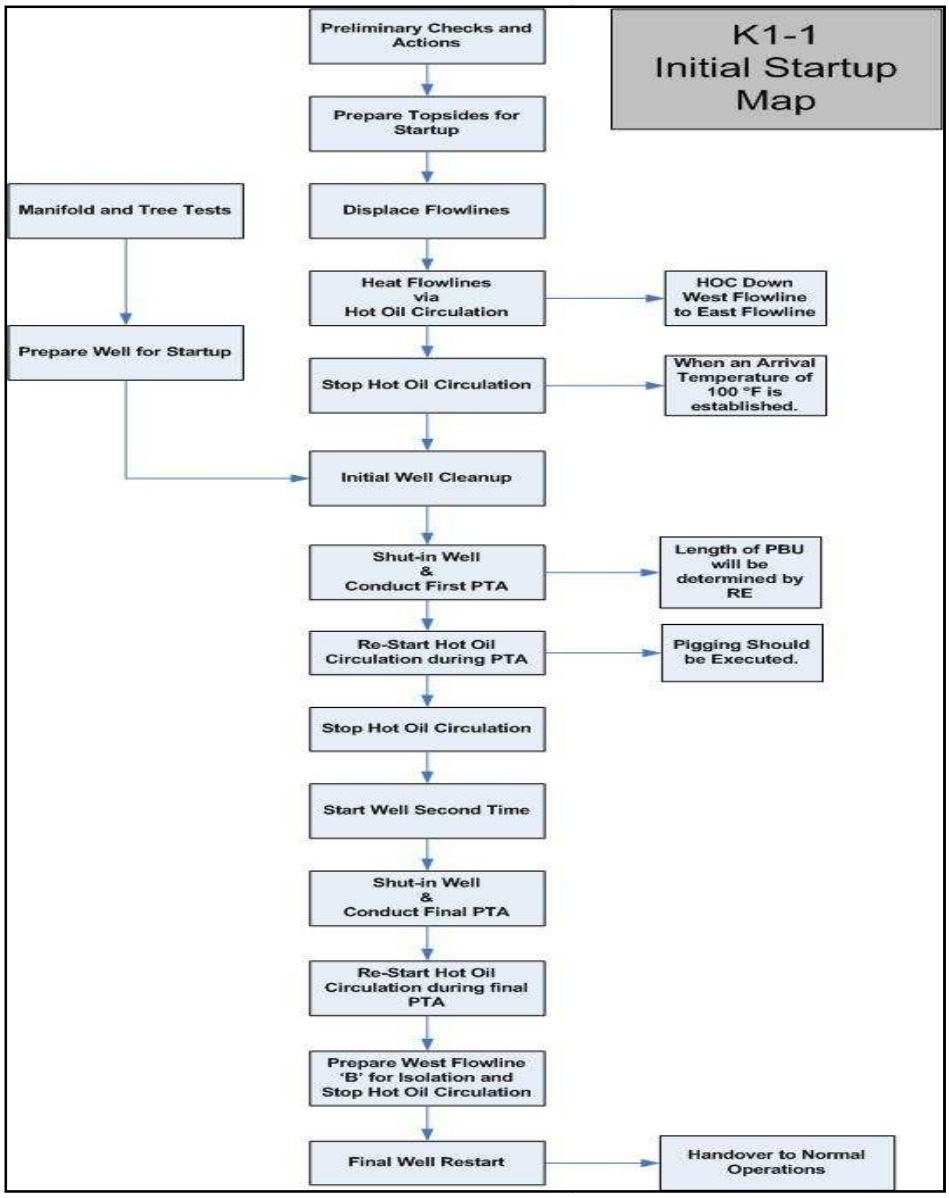
- People issues: Many people are required, often limited by POB (Persons on Board) limits. Responsibilities may be unclear and will change over the course of the startup.
- Initial use of much of the equipment only occurs during live hydrocarbon service. Problems are likely.
- Reservoir skin demands low flow rates initially and slow ramp-up rates. Chokes are often too large for effective control.
- Low flow rates and low temperatures yield significant hydrate risks.
- Flowback fluids are corrosive and difficult to treat.
- Construction, installation and commissioning activities may still be in progress. The exact state of equipment items may be unclear and changing.
- Special initial startup procedures are needed. These will differ in important ways from the normal operating procedures. Risks exist that there may be errors in the startup procedures, that operators may err in implementing them, and that equipment designed for normal operation will not function well at the conditions imposed by the startup.
- Pressure build-up tests performed to collect reservoir data are sensitive to interference and are easily disrupted by operator actions during the tests.
- Some regulatory requirements apply specifically to the startup period.

Initial startup is the first time the whole system has to work together. Many things can go wrong. Effective planning minimizes the risks.

Well integrity is critical during the initial startups as wells are produced for the very first time. What impact will the proposed subsea chokes have on the completion and near-wellbore area? Will additional backpressure be required? If so, will the facility be able to provide this pressure? Adequate flow modeling during this transient phase is critical so that proper operational procedures are developed. GATE has mastered multiphase choke modeling and as a result incorporated this knowledge into flow modeling programs for initial startups. These models provide correct guidance to operators as to what conditions to expect and detect if it is safe to

operate from a system integrity and flow assurance standpoint. The initial startup plan must also maximize the amount of information obtained for reservoir characterization and production optimization.

The main objectives of initial startup include:



- Execute initial startup safely
- Accomplish the cleanup without any un-permitted and unnecessary environmental discharges
- Effectively remove completion & fracture fluids from the well and reservoir
- Ensure protection of the entire system from the formation and deposition of solids (hydrates, paraffin, asphaltenes, scale, gelling, etc.) throughout the cleanup process
- Accomplish the cleanup without causing any damage to existing equipment
- Accomplish the cleanup without off-spec export oil except as previously agreed with the pipeline company
- Collect important well flowback data such as production rates, pressure transient data, well cleanup data, annulus pressure data, validate completion design/efficiency (skin assessment), confirm completion integrity with respect to sand control, subsea valve signatures, and more
- Ramp up production as quickly as possible without damaging the integrity of the completion
- Implement an effective sand management program
- Monitor and manage well annulus pressure

Keys to a successful initial startup:

- Start Early: Planning for startup should start early in the project
- Use a multi-disciplined team
- Use a system approach
- Build the plan in stages
- Risk management
- Training