BASIC PRINCIPLES OF FLOW CONTROL

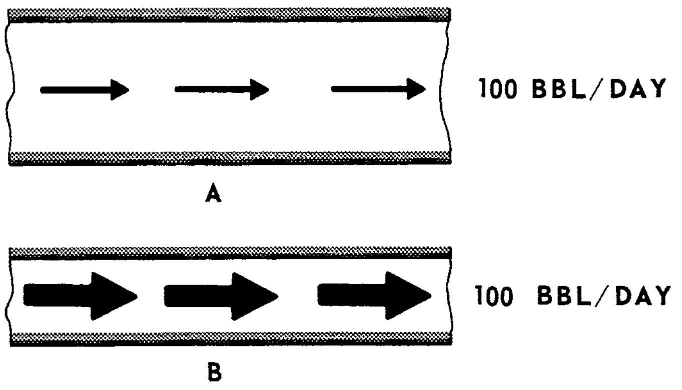
Effect of Pipe Size on Flow

83. If you pinch down the nozzle of a garden hose and the flow rate remains the same, the water flows (faster/slower) to get through the nozzle.

84. Pinching down the garden hose (increases/decreases) velocity in the nozzle.

85. Or, with the same flow *rate*, velocity is greater through a (larger/smaller) opening.

86. These two pipes have the same flow rate.



Velocity must be greater in line (A/B).

87. Suppose you wanted to increase the velocity of flow in a line.

    You could use a (smaller/larger) ID pipe.

88. To decrease velocity, you could use a ____________ pipe size.

89. Using a smaller ID pipe increases the velocity of flow.

    It also increases the amount of ____________.

90. Up to a point, you can increase velocity without affecting rate by using a smaller ID ____________.

91. Past that point, the smaller pipe creates too much ____________ to maintain the same rate of flow.

92. The *rate* of flow is controlled by controlling the pressure drop.

Without affecting rate, the *velocity* of flow can be controlled by the ____________ size used for the flow path.

93. To put flow at a high velocity without affecting rate, the pipe size used must be:

____________ enough to create the high velocity; and

____________ enough to prevent excessive friction.

94. Suppose a very *large* ID pipe is used for the flow path.

Velocity will be (fast/slow), and friction will (increase/decrease).

95. At low velocities, flow is laminar.

Fluids are more mixed together in (laminar/turbulent) flow.

96. Fluids are more likely to separate in the line in (laminar/turbulent) flow.

97. Separation of fluids is less likely if velocity is kept (high/low) enough to put the fluid in (laminar/turbulent) flow.

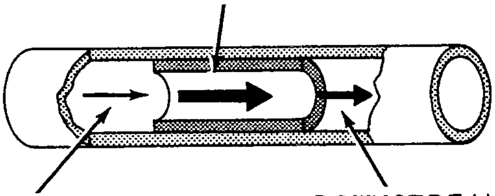
98. Higher velocities can be achieved by keeping the flow path ID fairly (large/small).

99. Most wells are produced through *tubing* which is a string of pipe about 2 inches or 2½ inches ID.

Production through tubing helps (cause/prevent) the separation of fluids in the well-bore by (increasing/decreasing) the velocity of flow.

Choking

100. In most flowing wells, the production rate is controlled by *chokes*.



A choke controls flow by (increasing/decreasing) the flow line ID.

101. The opening in the choke is called the ____________.

102. Chokes with smaller orifices restrict flow (more/less) than chokes with larger orifices do.

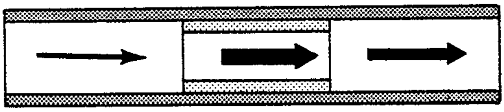
103. Before the flowing fluid reaches the choke, it is (upstream/downstream) from the choke.

104. After the fluid leaves the choke, it is (upstream/downstream).

105. The direction of flow across a choke is always ____________stream to ____________stream.

106. During flow, pressure is higher (upstream/downstream) from the choke.

107. As the fluid reaches the orifice of the choke, its velocity increases.



Friction (increases/decreases) at the orifice of the choke.

108. As the fluid speeds up to get through the orifice, its pressure decreases.

Velocity (increases/decreases) and pressure (increases/decreases) at the orifice of a choke.

109. After the fluid leaves the orifice, it encounters less resistance in the line.

As the fluid leaves the orifice, its velocity (increases/decreases) again and its pressure (increases/decreases) again.

110. Velocity is highest and pressure is lowest while the fluid is in the ____________ of the choke.

111. Pressure is higher in the downstream line than it is in the orifice.

But pressure in the downstream line is (higher/lower) than pressure in the upstream line.

112. The choke *creates* a pressure drop in the line.

This pressure drop is proportional to the increase in velocity and friction at the ____________ of the choke.

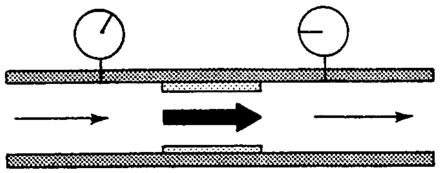
113. If a pressure gage is mounted on each side of the choke, the gages should record (the same/different) pressures.

114. Smaller orifices create higher velocities and (more/less) friction at the choke.

115. So, smaller orifices create (higher/lower) pressure drops in the line.

116. The effect of a choke (or any restriction) on the flow rate depends on the pressure drop created. These two lines have the same upstream pressure.

100 BBL/DAY

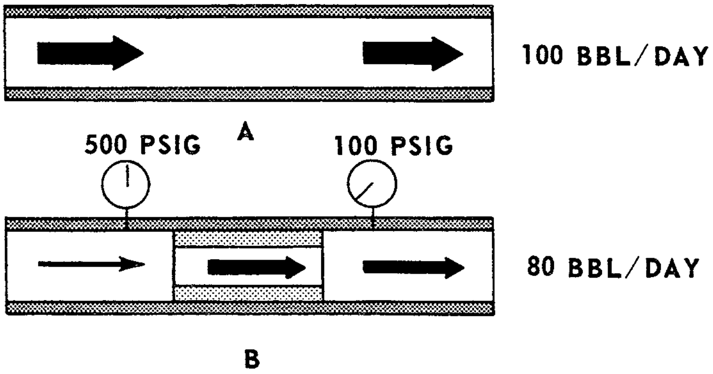


100 BBL/DAY

This restriction is not controlling the flow ____________ from the line.

117. The flow rates in the two lines are (the same/different).

118. Here is a choke that *is* controlling production.



This choke causes the pressure to drop from ________ PSIG to ________ PSIG.

119. The downstream pressure is (more than/less than) half of the upstream pressure.

120. A *pressure drop of 50%* means the upstream pressure is twice the downstream pressure.

Or, a pressure drop of 50% means the downstream pressure is (half/twice) the upstream pressure.

121. The pressure upstream from a choke is 4000 PSIG and the pressure downstream is 3000 PSIG.

The pressure drop is __________ PSIG.

122. This is (more than/less than) a 50% pressure drop.

123. To cause a 50% pressure drop with an upstream pressure of 4000 PSIG, a choke must reduce downstream pressure to less than __________ PSIG.

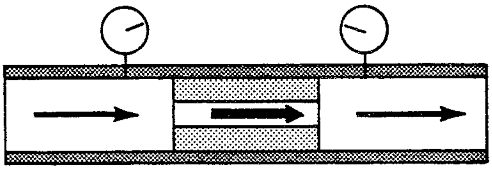
124. Pressure drops of 50% or more result from (larger/smaller) choke sizes.

125. In general, 50% is the dividing point between chokes that control production rates and chokes that don't.

When the pressure drop is more than 50%, the choke (controls/does not control) production.

126. When the pressure drop is less than 50%, the choke (controls/does not control) the rate.

127. Let's look at what happens when the pressure drop is greater than 50%.



As the fluid reaches the orifice, its velocity increases and friction also ____________.

128. With this choke, the friction created is too great for the flow rate to be maintained.

The fluid cannot supply enough pressure to maintain velocity and overcome ____________ at the same time.

129. As the fluid leaves the choke, its pressure increases again, but downstream pressure is still lower than upstream pressure.

This loss of pressure caused by the choke (increases/decreases) the flow rate in the line.

130. After a choke is installed, (more/less) fluid leaves the line in an hour or a day.

131. What happens upstream from the choke?

As velocity decreases, pressure ____________.

132. Chokes and other restrictions cause (an increase/a decrease) in pressure in the upstream line.

133. This pressure is called *back pressure.*

Back pressure is the pressure that builds up (upstream/downstream) from a choke or other restriction.

134. *All* restrictions in the flow line create some back pressure.

A partially-blocked path in the reservoir (can/cannot) create back pressure.

135. Friction in the lines also causes ____________ ____________.

136. As long as the flow rate is maintained through a restriction, there is not much build-up in back pressure.

If the rate is maintained through a restriction, the upstream velocity is not affected by the restriction.

If the upstream velocity is not reduced by the restriction, upstream pressure (increases/does not increase).

137. When back pressure builds, the pressure drops everywhere *upstream from the choke* are smaller.

So, the flow rate throughout the *upstream* line (increases/decreases) when a choke is used.

138. Or, back pressure *increases* the pressure drop across the ____________ and *decreases* the pressure drop in the (upstream/downstream) line.

139. A pressure drop across the choke measured at less than 50% on the pressure gages at the choke indicates that the back pressure build-up is (high/low) and that upstream flow (is/is not) slowed down by back pressure.

140. At pressure drops greater than 50% across a choke, back pressure probably (is/is not) building up in the line.

Critical Flow

141. Critical flow is a condition, like the "sonic boom" of jet aircraft, that occurs when flow reaches a certain critical *velocity* as it flows through an orifice.

Critical flow occurs (under any conditions/only under special conditions).

142. For any flowing fluid, the velocity for critical flow is the same as the speed of sound through the fluid.

When fluid is flowing through the choke at the same velocity that sound waves travel through the fluid, the line is in __________ flow.

143. To put a flowing gas in critical flow, a choke must create at least a pressure drop of about 50%.

At about a 50% pressure drop, the velocity of the gas going through the orifice is the same as the speed of __________ through the gas.

144. Denser and more viscous fluids require a higher pressure drop to be put in critical flow.

Technical personnel must __________ flow at a well to find the exact pressure drop needed to put a line in critical flow.

145. In critical flow, the flow rate does not change with changes in downstream pressure.

In lines *not* in critical flow, changing downstream pressure (changes/does not change) the upstream rate.

146. Except in critical flow, decreasing downstream pressure increases the rate.

Increasing downstream pressure (increases/decreases) the upstream rate when the line is not in critical flow.

147. When the fluid is in critical flow, the rate *cannot* be changed without changing the choke.

Once a fluid is "locked" in critical flow, nothing you do to the downstream pressure affects the __________ upstream.

148. When the pressure drop is more than 50%, the fluid probably is in critical flow.

When the pressure drop is *less than 50%,* the fluid probably is not in __________ flow.

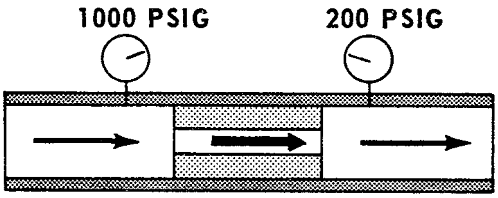
149. To put a line in critical flow, a choke must create a pressure drop that is greater than __________%.

150. In most oil fields, choke sizes are chosen to put a line in critical flow.

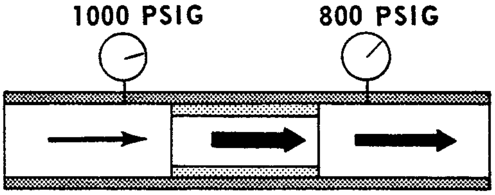
Then changes in the downstream pressure (affect/ do not affect) production from the well.

151. Minor changes in pressure in the surface lines or storage vessels (will/will not) change the rate of flow when the line is in critical flow.

152. Pressure gages are placed upstream and downstream of these two chokes.



A



B

The pressure drop is *less than* 50% in line (A/B).

153. Which line is more likely to be in critical flow? (A/B)

154. Changes in downstream pressure will affect the rate in line (A/B).

155. Unless the choke is changed or damaged, the production rate will not change in line (A/B).

156. Critical flow has a special application in multiple completion wells.

Suppose you are producing from two different reservoirs through the same well-bore.

You (would/would not) want changes in production from one reservoir to affect production from the other reservoir.

157. And, if you let the fluid from the two reservoirs commingle in one line, you would want to know how much fluid was being produced from each reservoir.

Therefore, critical flow is used to measure production from more than one reservoir through the same ____________.

158. Fluid from the higher pressure reservoir is kept in critical flow.

Then changes in downstream pressure do not affect the ____________ from that reservoir.

159. Once the production rate for critical flow has been measured, you (know/do not know) how much fluid is coming from the critical flow line in an hour or a day.

160. And you know that changes in downstream pressure (will/will not) affect production from the line that is in critical flow.

161. So, the fluid from the second reservoir can be fed in (upstream/downstream) from the choke that causes critical flow.

162. In the separating tanks, total production from the two reservoirs can be measured.

Then, to find the production from the second reservoir, you (add/subtract) the known production rate for the line kept in critical flow.

REVIEW AND SUMMARY

163. Anything that can be made to flow is a *fluid.*

All liquids and all ____________ are fluids.

164. Flowing wells are produced from the pressure of the ____________ in the reservoir.

165. Pressure is defined as:

____ potential, or stored energy.
____ kinetic, or moving energy.

166. Pressure is measured in ____________ per ____________ ____________ gage, abbreviated ____________.

167. The pressure of a fluid can be increased by:

(increasing/decreasing) the volume available to the fluid;

(increasing/decreasing) the temperature of the fluid.

168. Gases are (more/less) compressible than liquids.

169. Gases can be compressed into very small ____________.

170. Compressing a gas (increases/decreases) its pressure and (increases/decreases) its temperature.

171. Increasing the volume available to a gas (increases/decreases) its pressure and (increases/decreases) its temperature.

172. Density and specific gravity are measures of the ____________ of a fluid.

173. Liquids have (higher/lower) densities than gases.

174. Oil has a (higher/lower) density than water.

175. Hydrostatic pressure is caused by:

the ____________ of the liquid column;

the ____________ of the liquid in the column.

176. Hydrostatic pressure increases when either the ____________ or the ____________ of the liquid increases.

177. Hydrostatic pressure is always greatest at the (top/bottom) of a column of liquid.

178. The rate of flow is the ____________ of fluid produced in a given length of ____________.

179. Bbl./day is a measure of (volume/rate).

180. The kinetic, or moving, energy of a fluid is directly related to its ______________.

181. As velocity increases, pressure ____________.

182. As a fluid flows, some pressure is converted to ____________; some pressure is lost to ____________.

183. The flow rate can be increased by *increasing* the (inlet/outlet) pressure or by *decreasing* the (inlet/outlet) pressure.

184. The rate of flow is determined by the pressure ____________ in the line.

185. Increasing the pressure drop (increases/decreases) the flow rate through the line.

186. Without changing the rate, the velocity of flow can be increased by using a (larger/smaller) ID pipe.

187. Most wells are produced through tubing to (increase/decrease) the velocity of flow through the well-bore.

188. At higher velocities, flow is (laminar/turbulent).

189. Fluids are more mixed together in (laminar/turbulent) flow.

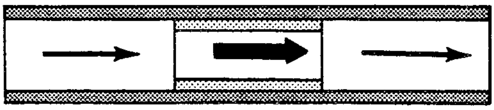
190. At higher velocities, fluids are (more/less) likely to separate from each other as they flow.

191. Wells are produced through tubing to (increase/decrease) the separation of fluids as they flow through the well-bore.

192. Chokes are used to decrease the ____________ of flow from the well-bore.

193. The direction of flow across a choke is ________stream to ________stream.

194. The choke creates a pressure drop in the flow line.



Pressure in this line is highest at (A/C).

195. Velocity and friction are greatest at ____________.

196. The pressure drop across the choke is the difference between the pressure at ____________ and the pressure at ____________.

197. Chokes with smaller orifices cause (larger/smaller) pressure drops.

198. To put a line in critical flow, a choke must create a pressure drop that is greater than ____________%.

199. In critical flow, changes in the downstream pressure (affect/do not affect) the upstream rate.

200. Critical flow is used in oil fields:

to maintain a ____________ rate from a flowing well;

to produce from more than one ____________ through the same well-bore.

201. Back pressure is the pressure that forms (upstream/downstream) from a choke or other restriction.

202. The more a choke reduces the flow rate, the more ____________ ____________ it puts on the upstream line.

THE END