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DATE: October 15, 1956

SUBJECT: Effect of Gas Sampling on the MRT Level Control

TO: R. L. Moore

FROM: R. F. Hughes

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OAK RIDGE NATIONAL LABORATORY

To: R. L. Moore

Date: October 15, 1956

Copies to: HRP Director's Office

Subject: Effect of Gas
Sampling on the
HRT Level Control

Rm 259, 9204-1

S. E. Beall

D. S. Toomb

K. W. West

M. I. Lundin

L. R. Quarles

P. W. Haubenreich

W. R. Gall

J. A. Lane

R. F. Hughes

Laboratory Records

During normal operation of the HRT, gas samples will be taken periodically; a question arises as to whether or not during this gas discharge from the reactor system, the restriction to flow through the vent line connecting the level indicator with gas pressurizer will cause sufficient pressure unbalance such that the indicator level will be an error resulting in mal-functioning of the reactor control system.

The conclusion reached, based upon the ensuing analysis, is that the vent line (1/4 inch schedule 80 tube) is sufficiently large to preclude a difference in reactor and indicator fluid levels during gas sampling.

Analysis:

For a duration of a few seconds, the rate change of reactor pressure while gas is being discharged from the reactor system may be represented by a constant:

$$(1) \quad \frac{dP_R}{dt} = -C$$

The rate change of gas pressure at the level indicator may be estimated from:

$$(2) \quad \frac{dP_I}{dt} = - \frac{\dot{m} P_{I_0}}{\rho V_I}$$

where $\dot{m}$ = gas mass flow through vent line lb/seg
 P_{I_0} = initial gas pressure at level indicator lb/ft²
 V_I = gas volume above fluid at level indicator ft³
 ρ = gas density lb/ft³

The gas density is taken constant throughout the analysis since the ratio between initial reactor operating pressure (2000 psia) and values of P_R and P_I is nearly one at all times.

An expression for the gas velocity in the vent line is:

$$(3) \quad v = \sqrt{\frac{2g (P_I - P_R)}{\rho(1 + fl/d + K_2)}}$$

where f = vent line friction coefficient
 l/d = vent line length to diameter ratio
 K_2 = vent line entrance, exit and bend loss in velocity heads

The gas mass flow through the vent line is given by:

$$(4) \quad \dot{m} = \rho A_v v = A_v \sqrt{\frac{2g \rho (P_I - P_R)}{1 + fl/d + K_2}}$$

Subtracting equation (1) from equation (2):

$$(5) \quad \frac{dP_I}{dt} - \frac{dP_R}{dt} = \frac{d(P_I - P_R)}{dt} = - \left[\frac{P_{I_0} A_v}{V_I} \sqrt{\frac{2g(P_I - P_R)}{\rho(1 + fl/d + K_2)}} - c \right]$$

Thus the maximum difference between P_I and P_R is given by:

$$(6) \quad [P_I - P_R]_{\text{maximum}} = \left[\frac{c V_I}{P_{I_0} A_v} \right]^2 \frac{\rho(1 + fl/d + K_2)}{2g}$$

Substituting the following representative values for the parameters,

$$\begin{aligned}
 C &= 15 \text{ lbs/in}^2 \text{ sec} = 2160 \text{ lbs/ft}^2 \text{ sec} \\
 V_I &= .029 \text{ ft}^3 \\
 P_{I_0} &= 2000 \text{ lbs/in}^2 \\
 A_V &= .072 \text{ in}^2 \\
 \rho &= 5.5 \text{ lbs/ft}^3 \\
 fl/d &= 13 \\
 K_2 &= 2.3
 \end{aligned}$$

$$\begin{aligned}
 (P_I - P_R)_{\text{maximum}} &= \left[\frac{2160 \times .029}{2000 \times .072} \right]^2 \frac{5.5 \times 16.3}{64.4} = .26 \text{ lbs/ft}^2 \\
 &= \frac{.26 \times 12}{50} = .062 \text{ inches of fluid}
 \end{aligned}$$

This pressure difference is not critical to operation of the reactor fluid level control.

/mh

R. F. Hughes
R. F. Hughes

0-3