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Potential Difficulties with the Halonyzer II with Respect to "Real-Time" Data Gathering

Work with the analyzer over the last year has provided situations where the data did not appear intuitively correct. The result was a conclusion that the concentration profiles described unrealistic behavior. Given the data observed during recent testing, the recorded agent concentrations were not at the extinguishing design concentration when the initial suppression occurred. After review, a problem with the analyzer with respect to its ability to catch a "real-time" concentration profile has been realized. This started an informal review process to find out why this was so.

To address the issue practically, the review considered possible explanations which might have allowed suppression at lower than expected concentrations. After results were reviewed, no other reason beyond the presence of the agent itself was believed to be responsible for the fire extinguishment.

Having put alternate explanations exclusive of the analyzer aside, the review continued with an in-house evaluation of the analyzer itself. Considerations of the transducer response, diffusion of the agent concentration during transport to the transducer, and the time for sample transport to the transducer were considered. Of these, the time for the sample transport across the probe to the transducer appeared as the largest part of the reason for discrepancy. Consider the following circumstances:

1. Where the following variables are describing:

Table 1. Variable Call Outs

variable	description	dimension
Q =	volumetric air flow	$(\text{length})^3$/time
V =	internal volume	$(\text{length})^3$
A =	cross sectional area of the duct or tube	$(\text{length})^2$
L =	length of the duct or tube	(length)
f =	scaling factor	dimensionless

subscript "E" refers to engine.
subscript "T" refers to the tube the Halonyzer sample passes through.

2. The Halonyzer is properly configured to perform a concentration test while attached to a nacelle.
3. A Halonyzer probe draws air at certain compartment ventilation rate, Q_T/V_T.
4. The nacelle compartment where the Halonyzer is sampling is changing at another compartment ventilation rate, Q_E/V_E.
5. The process remains steady state during evaluation.

Ultimately, it can be seen by the workings in Figure 1 that the samples moving through the probe and nacelle are reduced to factors of probe length and velocities for the gas streams in either volume. When grouping these variables, the factor "f" is introduced as a scaling factor. To get "real-time" data gathering from the analyzer, the factor of

"$f*(L_E/L_T)$" must approach unity; otherwise a time dilation occurs to the data record stored by the analyzer.

To further explain. The transducers and electronics in the analyzer are capable of recording down to 100 Hz resolution. This rapid data gathering ability is not meaningful if the gas flow passing through the probe is at a velocity other than the nacelle velocity. The rapidly gathered data from the transducer describes the event in terms of the flow constraints for the probe and vacuum pump, not what is actually occurring in the nacelle.

$$\frac{Q_E}{V_E} = f * \frac{Q_T}{V_T}$$

$$\Rightarrow Q = A * \dot{x}$$

$$\Rightarrow V = A * L$$

$$\Rightarrow \frac{Q}{V} = \frac{A * \dot{x}}{A * L} = \frac{\dot{x}}{L}$$

$$\therefore \dot{x}_E = f * \left(\frac{L_E}{L_T}\right) * \dot{x}_T$$

Figure 1. Flow Evaluation

To nullify this effect, the probe internal volume was considered the primary variable to address for the solution of the problem; increase the compartment ventilation rate in the probe so it is either the same or exceeds the compartment ventilation rate for the nacelle. This is reflected by minimizing the probe internal volume, shown as "V_T", in figure 1. By doing this, the overlying goal would be to send the factor "f" toward unity, or even a smaller magnitude; allowing a near alignment of the timelines for both gas streams.

Granted, there are several underlying issues which remain to complicate the issue further. However, from an engineering perspective, in-house work has shown the variation between near square-wave and probe-based signals is minimal. Figure 2 illustrates the

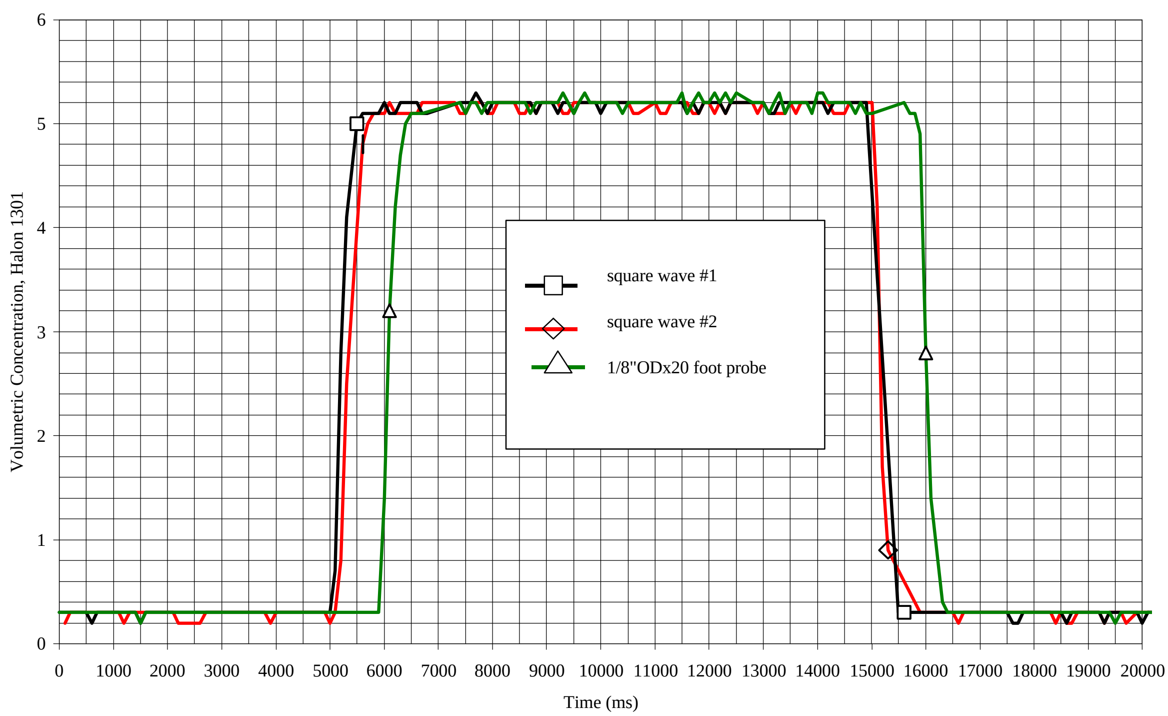

Figure 2. Halonyzer Response Illustration

condition for 1/8" OD sample probe. As shown in figure 2, the difference between the near-square-wave and the actual probe profiles is approaching that of a pure time displacement. Based upon this notion, measurements can be taken to correct such time offsets to fully explain the interactions in the nacelle. The two different near-square-waves are shown to verify the device providing the gas to the analyzer is still susceptible to diffusive dynamics as the gas enters the mixing chamber, and is not a transducer response problem.