Safety Hazard Tests for Holiday Detectors

Pipeline Inspection Company Ltd.

There is a common misconception that "high voltage" also means unsafe. The real truth is that the device furnishing the voltage must also be capable of furnishing "high current" before it is considered dangerous.

The laws of physics determine that if a spark is to jump an air gap of any distance, then the voltage must have an amplitude high enough to overcome the dielectric strength of the air gap. An example of this is the spark plug and spark coil in an automobile. In order to ignite the fuel in the cylinder a spark is required. The size of the spark required for a given cylinder size and fuel to air ratio will determine a spark plug with a certain size gap for best combustion. With this specification in hand, computations and/or testing is then done to determine how much voltage is required to furnish that spark. Once that has been accomplished, the spark coil is designed to yield an output of the desired voltage but it is also designed to output a limited amount of current.

The design of holiday detectors is somewhat similar to the spark plug design. The protective coatings used on pipelines vary widely but let us use the example of coal tar enamel that is applied with a thickness of 3/32" (93.8 mils). The National Association of Corrosion Engineers (N.A.C.E.) recommends using a voltage of approximately 1250 times the square root of the thickness (in mils). As we can see, this yields a voltage of approximately 12,106 volts (1250 x 9.685). While this may seem like a large voltage, the real safety concern is that of whether or not the holiday detector is capable of supplying an adequate current or an unsafe current at that voltage.

Several studies have been done, by other organizations, to determine what represents a safe current. See Table 1 for a partial list of these values. While these studies typically centered around normal household current (with the wave shape of a sine wave) it is important to say here that the output voltage of a holiday detector is a pulse output. This means that once the waveform begins, the majority of the energy occurs within the first portion of the cycle whereas a sine wave output has an energy level throughout the cycle. This also means the pulsed output of the holiday detector would yield much lower values than those of pure sine wave if one uses the same formulas that were used to determine the voltages and currents of a pure sine wave.

Current	**Effects**
1 ma or less	**Causes no sensation. No feeling.**
1 ma to 8 ma	**Sensation of shock. Individual can let go at will as muscular control is not lost.**
8 ma to 15 ma	**Painful shock. Individual can let go at will as muscular control is not lost.**

Table 1

Before there is any current flow you must have a complete circuit. As you may have seen workman for the local power and light company doing, you can touch one side of a power line without getting shocked, **AS LONG AS YOU DON'T TOUCH THE COMMON**, or you are not grounded yourself. You can keep from being grounded by wearing rubber boots, standing on a rubber mat or many other ways. The important thing is that you do not want to complete the circuit. Using elementary electrical formulas, it can be shown that resistance impedes electrical current flow (current flow = voltage/resistance). The studies referenced above have determined the approximate resistance of the human body shown in Table 2.

Within the area of transformer design, you can also limit the output power of a circuit. In order for a transformer to function, you must supply one side (the primary) with a changing voltage, the electromagnetic coupling to the secondary creates a voltage output.. Power transformation theories say that, “power in equals power out”, however, it is also known that transformers are not 100% efficient and therefore the power output is reduced by this inefficiency. The electro-magnetic coupling described above is a key to limiting the output current of the transformer. Once it has been determined what the output power should be, then the design of the transformer is such that once it reaches this value, the magnetic coupling saturates and it becomes physically impossible for the transformer to generate any more power.

Skin condition	**Resistance**
Dry skin	**100K to 600K ohms**
Damp skin	**40K ohms**
Wet skin	**1K ohms**

Table 2

We have performed tests periodically over the years to verify the output currents of our holiday detectors and have consistently found the currents to be within a safe margin. The following paragraphs briefly describe the test methods and the results for various holiday detectors.

For the following tests, the peak current was measured, as shown in Fig.1. It is normal for average current to be computed using formulas for a pure sine wave. (Average current = peak current divided by the square root of 2). Since the detector output waveform is a pulse type it is actually more accurate to use the formula for non-sine waves which adds the baseline to the product of the duty cycle and amplitude. The tests used two values of load resistance, 1K ohm and 40K ohm. The lower resistance value would represent the “worst case” condition. It should be noted that the voltage for Test 2, for all detectors, is lower because again, the output transformer is designed to furnish a limited power and it is therefore inherent that the more the load (the higher the current) the lower the voltage becomes.

It can be seen from these tests that the average output current (Ip) from these detectors is well within safe limits. However, caution should always be used when one is working around high voltages.

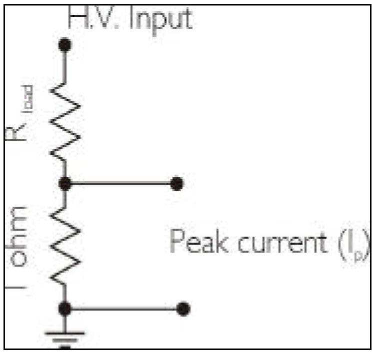

Fig. 1

Test set-up for measuring peak current I_p

Formulas Used

Duty cycle = $(t_o)/t_t)$

I_{avg} = baseline + (duty cycle) x (I_p)

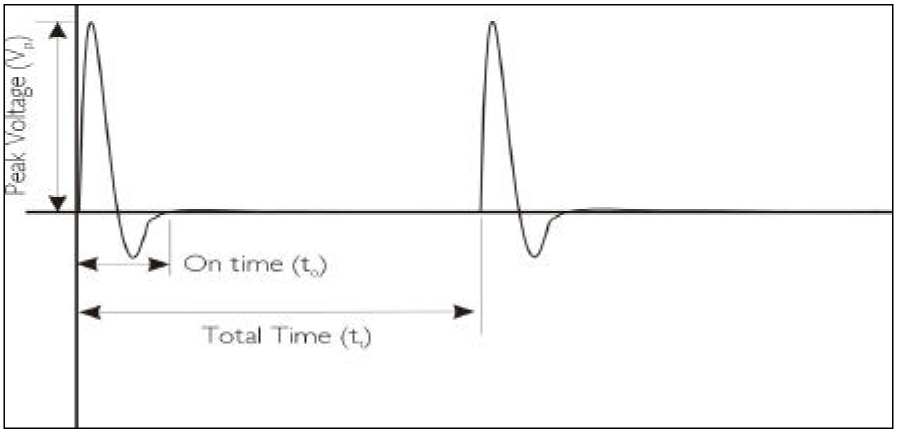

Fig. 2

Detector	R_{load}	V_p	t_o	t_t	Duty cycle	I_p	I_{avg}
Model 115							
Test #1	**40,000**	**5,000**	**100 uS**	**8 mS**	**0.0125**	**0.24 A**	**3.00 mA**
Test #2	**1,000**	**2,000**	**22 uS**	**8 mS**	**0.0028**	**1.52 A**	**4.26 mA**
Model 125							
Test #1	**40,000**	**20,000**	**300 uS**	**36 mS**	**0.0083**	**0.90 A**	**7.47 mA**
Test #2	**1,000**	**5,000**	**50 uS**	**36 mS**	**0.0014**	**1.46 A**	**2.04 mA**
Model 715							
Test #1	**40,000**	**2,000**	**15 uS**	**8 mS**	**0.001875**	**1.0 A**	**1.875 mA**
Test #2	**1,000**	**1,200**	**15 uS**	**8 mS**	**0.001875**	**1.0 A**	**1.875 mA**
Model 725							
Test #1	**40,000**	**15,000**	**40 uS**	**27 mS**	**0.00148**	**0.6 A**	**0.9 mA**
Test #2	**1,000**	**3,000**	**50 uS**	**27 mS**	**0.00185**	**1.4 A**	**2.6 mA**
Model 735							
Test #1	**40,000**	**30,000**	**24 uS**	**31 mS**	**0.00077**	**1.0 A**	**0.77 mA**
Test #2	**1,000**	**15,000**	**60 uS**	**32 mS**	**0.00188**	**1.9 A**	**3.56 mA**

Table 3

`Test Results`

Bibliography:

Buchsbaum, Walter H. Buchsbaum's Complete Handbook of Practical Electronic Reference Data, Second edition

Andreoli, Kathleen G., et al., Comprehensive Cardiac Care: a text for nurses, physicians, and other health practitioners, Third edition.

Pipeline Inspection Co., Ltd. Product testing 1990/2000.