♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

LD-3 SERIES

Rigid Dielectric Cell

Instruction Manual

Effectivity: Serial Numbers beginning with E1
LD-3 - LD-3T im/August, 2013

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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTIBILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

WARNING

OBSERVE ALL SAFETY RULES
'WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

ELECTRICAL SHOCK HAZARD. DO NOT OPEN CASE.
REFER SERVICING TO QUALIFIED PERSONNEL.

HIGH VOLTAGE MAY BE PRESENT WITH **HIGH VOLTAGE OPTIONS.**

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS:

- USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS.

REMOVE POWER WHEN HANDLING UNIT.

POST WARNING SIGNS AND KEEP PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

TABLE OF CONTENTS:

DESCRIPTION: THE MODEL LD-3 OR LD-3T IS A MANUAL TEST CELL (SAMPLE HOLDER) FOR MEASURING THE DIELECTRIC CONSTANT AND THE DISSIPATION FACTOR, OF SOLID INSULATING MATERIALS.

THE LD-3 OR LD-3T IS A THREE TERMINAL CELL,WITH TWO FIXED ELECTRODES AND ONE MOVEABLE ELECTRODE. THE OUTER ANNULAR RING IS A GUARD RING, AT GROUND POTENTIAL. THE INNER GUARDED RING IS AT A LOW POTENTIAL. THE MOVEABLE ELECTRODE IS AT THE HIGH POTENTIAL.

THE CELL CAN BE USED WITH AN SUITABLE BRIDGE OR CAPACITANCE MEASURING INSTRUMENTS.

THE CELL CAN BE USED FROM 60HTZ -- 1 MHZ. FREQENCY.

THE ADVANTAGE OF THIS CELL IS THAT THERE IS NO NEED TO PLATE ON ELECTRODES OR THE USE OF MERCURY.

THE NORMAL TYPE OF MEASUREMENT WOULD BE TO USE THE CONTACTING ELECTRODES. PROVIDED THAT THE SAMPLE IS THICK, FLAT OR COMPLIANT.

THE MORE ACCURATE TYPE OF MEASUREMENTS WOULD BE EXAMINED IN EID 11"DIELECTRIC LOSS AND PERMITTIVITY MEASUREMENTS WITH GEN-RAD PRECISION CAPACITANCE BRIDGES",THIS ARTICLE IS PROVIDED IN THE MANUAL.

SPECIFICATIONS:

SIZE: 4.0" X 4.0" DEEP X 7.5" LENGTH

WEIGHT: LD-3T 8.180 lbs.

MATERIALS: 303 STAINLESS STEEL, TEFLON, BRONZE (LD-3T)

TERMINALS: THREE TERMINAL (WITH GUARD RING),
POSITION: VERTICLE

CONNECTORS: LOW TERMINAL - G/R-0874 (SHELL IS AT GROUND)GUARD
HIGH TERMINAL - BANANA JACK

ELECTRODES: GUARD RING - O.D. 2.87 ; MEASURING ELECTRODE 2.5 ;
MOVEABLE ELECTRODE 2.87

OPENING: 0 ---- 0.350 IN.

SAMPLE SIZE: 0.005 --$\frac{}{2}$- 0.350 IN.(THK.) X 2.87 IN. (O.D.) OR
2.87 IN ^{2}

SPACING READOUT: MICROMETER, 0 --- 0.5000, 0.0001 RESOLUTION

FREQUENCY: 60 HZ. ----- 1.0 MHZ. (10 MHZ. REDUCED ACCURACY)

TEMPERATURE RANGE: - 100 F° ---- + 400 F° (LD-3T)

SHIELDING: THE UNIT IS WELL SHIELDED, BUT FOR COMPLETE SHIELD-
ING, YOU MUST USE THE OPTIONAL COVER.

MEASURING INSTRUMENTS: ANY CAPACITANCE BRIDGE OR LCR INSTRUMENT.

ELECTRODES SIZE (ACTUAL)

YOUR SERIAL NO. S/N: _____

ELECTRODE (MEASURING)

O.D. 2.5000 IN, UNCOATED
O.D. 2.5150 IN. COATED
THK. 0.1720 COATED
THK. 0.165 IN. UNCOATED

GUARD RING

O.D. 2.8766 IN.
I.D. 2.5150 IN.
THK. 0.248 IN.

MEASUREMENT METHODS:

CONTACTING ELECTRODES:	SEE PAGE FIVE OF EID 11
AIR GAP METHOD:	SEE PAGE SIX OF EID 11
TWO FLUID METHOD:	SEE PAGE SIX & SEVEN OF EID 11
LIQUID MEASUREMENT:	SEE PAGE SEVEN OF EID 11, (USE MODEL 350G CELL.)

CALIBRATION:

DO NOT TIGHTEN THE ELECTRODES WITH EXCESSIVE FORCE OR YOU WILL DAMAGE THE CELL,ELECTRODES, MICROMETER OR EFFECT CALIBRATION.

DO NOT REMOVE THE MICROMETER FROM THE END PLATE. THIS IS FACTORY SET.

DO NOT TURN THE MICROMETER SLEEVE WITH THE SPECIAL WRENCH PROVIDED, BECAUSE THIS IS FACTORY CALIBRATED, UNLESS YOU ARE DOING YOUR OWN CALIBRATION.
THE FACTORY CAL. MATCHES THE CAL. SHEET PROVITED.

THE MICROMETER IS ADJUSTED TO READ 0.010 WHEN THE BRIDGE IS SET TO 110.615 pf (uuf) (pf = 1.0 x 10^{-12} FARADS)

YOU MAY NOTICE THAT WHEN YOU CLOSE THE ELECTRODES ALL THE WAY THAT THE MICROMETER WILL NOT QUITE READ 0.0000 THIS IS NORMAL.

THIS CALIBRATION IS DONE WITH A GEN/RAD BRIDGE 1620A ±.01 % ACCURACY. SENSITIVITY OF ONE PART/ MILLION.

FORMULAS:

e_r RELATIVE PERMITTIVITY OF DRY AIR 1.00053
VACUUM 1.0000

$$e_r = \frac{C_x}{C_o}$$

C_x = CAPACITANCE OF UNKNOWN

C_o = CAPACITANCE OF ABOVE CONDTION WHEN THE SPACE IS FILLED WITH VACUUM(OR AIR)

e_r = DIELECTRIC CONSTANT
k

$$C_{HL}\ \text{uuf (pf)} = 0.22489 \times \frac{A\ (\text{eff.})\ IN^2}{t\ IN} \times e_r$$

A = AREA (EFF) OF MEASURING ELECTRODES 4.921558688 IN^2(EFF.)

C_{HL} : CAPACITANCE AS MEASURED WITH UNKNOWN BETWEEN ELECTRODES

t = THICKNESS OF SAMPLE (DISTANCE BETWEEN ELECTRODES)

e_r = USE 1.000 (FOR AIR)

$$^*A = \frac{D^2(\text{eff})}{2} \times \pi$$

$$^*D\ (\text{eff.}) = \frac{D_2 - D_1}{2} + D_1$$

D_2 = 2.5150 IN. YOUR ELECTRODE(AFTER COATING)

D_1 = 2.5000 IN. YOUR ELECTRODE (BEFORE COATING)

$^*D$ (eff) = 2.5075 IN YOUR EFFECTIVE O.D. OF ELECTRODE (USE IN FORMULA ABOVE)

INSTRUCTIONS:

PLACE SAMPLE BETWEEN ELECTRODES AND TURN MICROMETER BARREL UNTIL YOU MAKE CONTACT WITH THE SAMPLE.
TRY TO MINIMIZE ANY AIR GAP,BUT DO NOT SQUEEZE THE SAMPLE TOO TIGHT,BECAUSE YOU WILL DAMAGE THE MICROMETER THEADS OR EFFECT CALIBRATION.

INSTALL THE CABLE MARKED 1688-9600 INTO THE TWO SLOTS ON TOP OF THE DIGIBRIDGE G/R 1658,MATCH THE RED DOTS.

AFTER ALLOWING THE BRIDGE TO WARM UP FOR AT LEAST ONE HOUR, YOU MAY SET THE SWITCHES.

PRESS	DISPLAY	TO OBTAIN	VALUE
PRESS	MEASURE RATE	TO OBTAIN	SLOW
PRESS	EQUIVALENT CIR.	TO OBTAIN	
PRESS	FREQUENCY	TO OBTAIN	120 HZ OR 1 KHZ
PRESS	MEASURE MODE	TO OBTAIN	AVERAGE
PRESS	C/D	TO OBTAIN	CAPACITANCE

DO NOT CONNECT CELL END OF CABLE YET,YOU MUST TAKE AN EMPTY READING. HOLD END OF CABLE AWAY FROM ANY OBJECTS AND SEPARATE ENDS BY 24 INCHES.

PRESS START TO OBTAIN EMPTY READING

YOUR UNIT EMPTY READING 1.47 pf

NOW INSTALL CABLE ENDS INTO THE CELL (LD-3 or LD-3T)

INSTALL SAMPLE AS NOTED ABOVE AND TAKE A READING.

READING _____

SUBTRACT EMPTY READING _____

SAMPLE CAPACITANCE _____

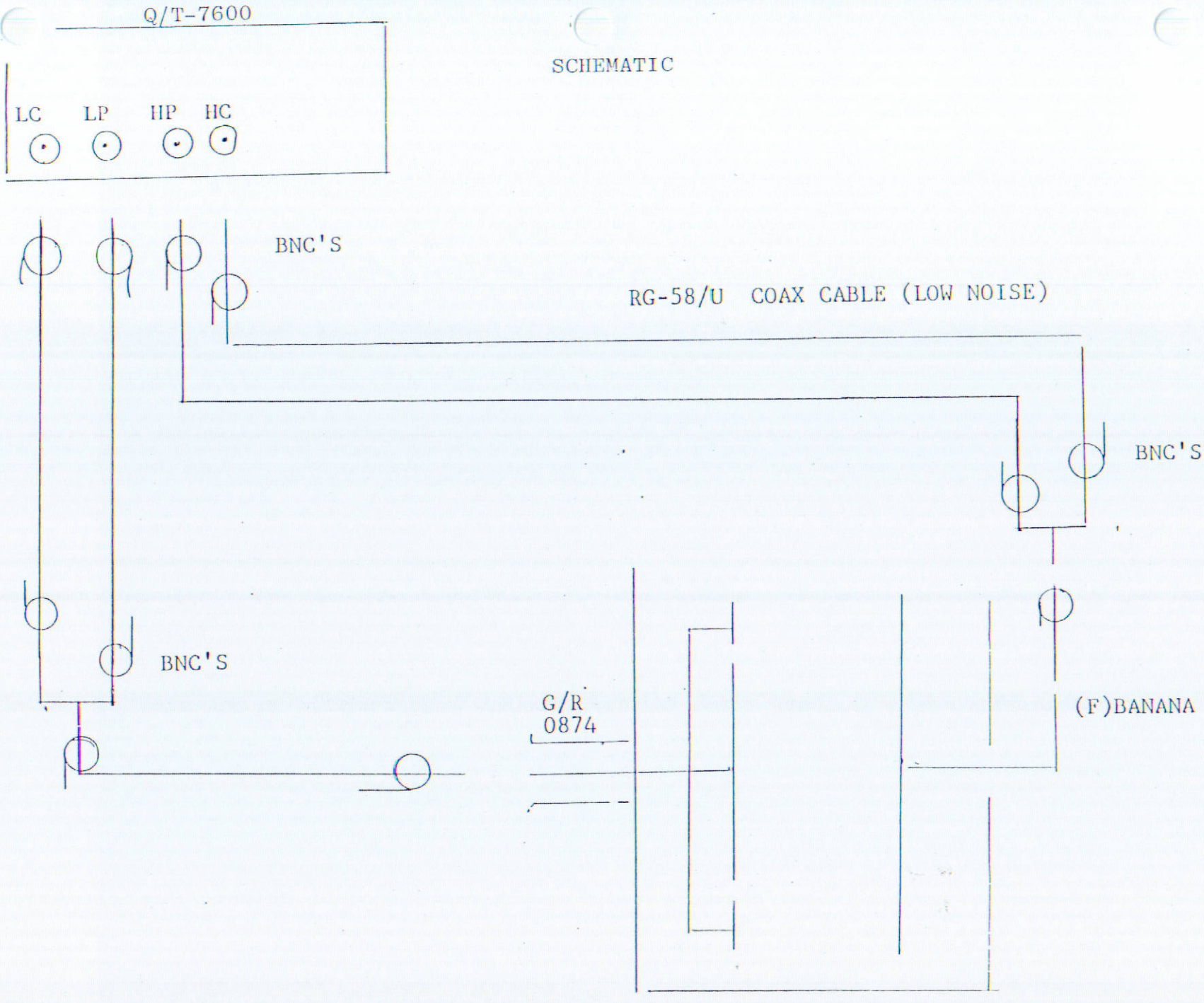
REMOVE SAMPLE AND PLACE THE MICROMETER AT THE SAME SETTING TO THE NEAREST TEN THOUSANDTH 0.0001

TAKE A READING OPEN CELL CAPACITANCE _____

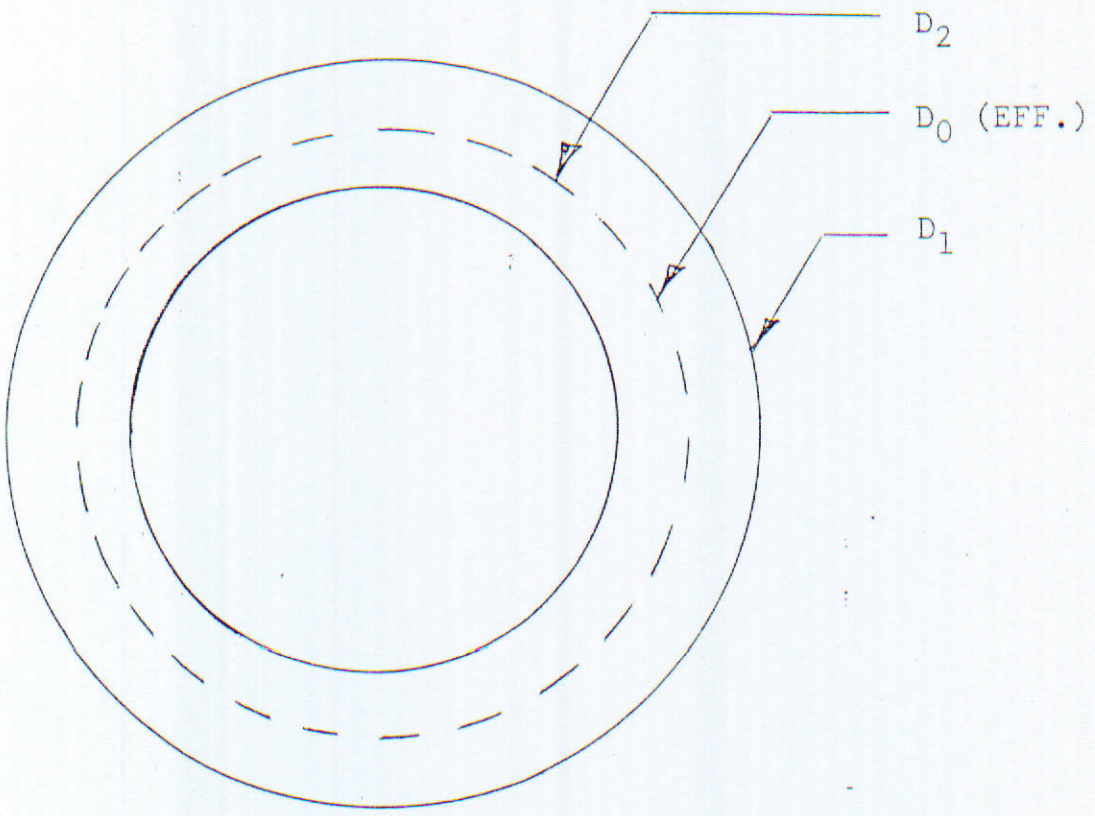
INSTRUCTIONS CONT.-

NOW DIVIDE THIS READING INTO THE PREVIOUS READING OF THE SAMPLE, TO OBTAIN THE DIELECTRIC CONSTANT.

DIELECTRIC CONSTANT $e_r = \frac{C_X}{C_O}$ SAMPLE CAPACITANCE / AIR CAPACITANCE


Q/T-7600
LC
LP
HP
HC
SCHEMATIC
BNC'S
RG-58/U COAX CABLE (LOW NOISE)
BNC'S
BNC'S
G/R
0874
(F)BANANA
LD-3

DRAWING ELECTRODES: FIXED ELECTRODE WITH GUARD RING



D_2 --- GUARD RING I.D. OR MEASURING ELECTRODE O.D. (COATED,TEFLON)

D_1 --- MEASURING ELECTRODE O.D. (UNCOATED)

D_0 --- EFFECTIVE O.D. (USE IN CALCULATIONS)

D_0 --- CALCULATION $$D_0 = \frac{D_2 - D_1}{2} + D_1$$

EXAMPLE: 1.) FREQUENCY --- 1.0 KHZ, TEMPERATURE --- 70.0 F°

SUBJECT: TO DETERMINE DIELECTRIC CONSTANT OF SAMPLE (UNKNOWN)

EQUIPMENT: G/R 1658 DIGIBRIDGE (S/N:)

LD-3 OR LD-3T (S/N:)

SAMPLE: TEFLON (MIL.STANDARD)
LAPPED FLAT AND PARALLEL 50 MILLIONTHS
S/N:

STEP: 1. MEASURE THICKNESS OF TEFLON SAMPLE, TAKE AT LEAST FIVE READINGS, TO THE NEAREST TEN THOUSANDTH OF AN INCH.

RECORD RESULTS SAMPLE THICKNESS AVERAGE _____

STEP: 2. PLACE TEFLON SAMPLE IN SAMPLE HOLDER, THEN TIGHTEN ELECTRODES USING MICROMETER, DO NOT OVER TIGHTEN

RECORD RESULTS (DO NOT FORGET TO SUBTRACT EMPTY READING.

RESULTS (SAMPLE) _____ pf

EMPTY READING (CABLES CONNECTED AT BRIDGE END ONLY)

SUBTRACT _____ pf

C_x RESULTS SAMPLE CAPACITANCE C_0 RESULTS _____ pf

STEP: 3. RECORD MICROMETER READING TO THE NEAREST TEN THOUSANDTH OF AN INCH.

RECORD _____ IN

STEP: 4. REMOVE SAMPLE AND PLACE MICROMETER IN THE EXACT POSITION AS IT WAS IN STEP 3. (TO THE NEAREST TEN THOUSANDTH OF AN INCH.

RECORD CAPACITANCE READING (AIR CAPACITANCE) _____ pf

SUTRACT EMPTY READING AS YOU DID BEFORE _____ pf

C_0 RESULTS AIR CAPACITANCE _____ pf

STEP: 5. CALCULATE THE DIELECTRIC CONSTANT:

(NO UNITS) (pf) (pf)

e_r $e_r = C_x / C_0$ (AIR) RESULTS: _____

CLEANING INSTRUCTIONS:

TO CLEAN THE CELL REMOVE THE TWELVE SCREWS FROM THE SIDE PLATE OF THE LD-3 OR LD-3T.(use the allen wrench provided).

FOR MOST LIGHT CLEANING THIS WOULD BE ENOUGH DISASS-EMBLY. BE CARE-FULL NOT TO SCRATCH OR DAMAGE THE ELECTRODES. THE INSIDE OF THE SIDE PLATE OR THE MATING EDGE THE MAIN BODY OF THE CELL. ALL THESE SURFACES ARE GROUND AND LAPPED. THESE SURFACES ARE EXTREMLY FLAT.

A GOOD GENERAL PURPOSE SOLVENT WOULD BE A LABORATORY GRADE METHYL-ALCOHOL LEAVES LITTLE RESIDUE.

FOR A COMPLETE CLEANING AND DISASSEMBLE CONSULT THE FACTORY.

EXAMPLE: (CONT.) FREQUENCY --- 1.0 KHZ, ---- 70.0 F°

P: 6. COMPARE YOUR RESULTS WITH FACTORY CALIBRATION.

CUSTOMER	FACTORY	FACTORY
_____	G/R 1658	G/R 1620A

CABLE INFORMATION:

ALL ROOM TEMPERATURE COAX CABLES ARE SPECIAL LOW NOISE CABLE.

COAX TYPE: RG-58/u

MANUFACTURE: BELDON

PART NUMBER: 9223

d: THE OUTSIDE DIAMETER OF INNER CONDUCTOR IN INCHES. 0.030 IN.

D: THE INSIDE DIAMETER OF THE OUTER CONDUCTOR IN INCHES. 0.1120 IN.

E: 2.3 POLYETHYLENE (DIELECTRIC CONSTANT) THE DIELECTRIC OF THE INNER INSULATION

P.F. THE POWER FACTOR OF THE INNER INSULATION: 0.0003

V.R. VOLUME RESISTIVITY (POLYETHYLENE) 1.0×10^{16} OHMS-CM.

NORMAL OPERATING TEMPERATURE: -75 -- 80 C°

CAPACITANCE: 29.59 uuf/FT.

INDUCTANCE: 80.08 uH/FT.

IMPEDANCE: 50.0 OHMS (CONSTANT) FOR ANY LENGTH

VELOCITY OF PROPAGATION: AS % OF THE SPEED OF LIGHT 65.938 %

FORMULARS:

CAPACITANCE: $\underset{\text{uuf/FT.}}{(C)} = \dfrac{7.36\ E}{\text{Log. } (D/d)}$

INDUCTANCE: $\underset{\text{uH/FT.}}{(L)} = 140 \text{ Log.}(D/d)$

IMPEDANCE: $(Zo) = \sqrt{\dfrac{L}{C}} = \dfrac{138}{\sqrt{E}}$

VELOCITY OF PROP.: (% of the speed of light) $\% = \dfrac{100}{\sqrt{E}}$

ACTUAL SPECIFICATIONS:

G/R-0874, BNC (RT.ANGLE) LENGTH: 39.125 IN.

LOW SIDE

CAPACITANCE: 96.476 uuf
INDUCTANCE: 261.092 uH

BNC(M), BANANA (M) LENGTH: 42.0 IN.

HIGH SIDE (RED)

CAPACITANCE: 103.565 uuf
INDUCTANCE: 282.38 uH

DATE: 8/15.13

CALIBRATION DATA

ELECTRODES
GUARDED UNCOATED O.D. 2.5000 IN. COATED O.D. 2.5150
GUARD RING I.D. THK.
GAP
GUARDED O.D. (EFFECTIVE) (USE IN CALCULATIONS) 2.5075 IN.

ENGINEER: G.GILKIE LOCATION: WATERTOWN, MA.

BRIDGE: GEN/RAD MODEL: SIN.: ACC.:

DATA:

SET MICRO.

SPACING INCHES	SPACING CM	CAL. μμf	ACTUAL μμf	ERROR Δ	ERROR %	CAL.	ACTUAL	ERROR %	ε_r
0.005		222.1119	225.65	3.598	1.59 %				
0.010		111,0559	111.0559	0,0	0.0				
0.020		55.527	55.505	0.0229	0.041				
0.025		44.422	44.565	0.433	0.32				
0.050		22.211	22.313	0.102	0.45				
0.100		11.105	11.184	0.0785	0.706				
0.200		5.5523	5.584	0.032	0.567				
0.250		4.442	4.456	0.014	0.315				
0.300		3.701	3.696	0.0054	0.145				

FORMULA: $C_{HL} = 0.08854 \times E \frac{A\ CM^2}{h_o\ SEP.\ CM}$ $C_{HL} = 0.22489 \times E \frac{A\ IN^2}{SEP.\ IN}$ pf

A = AREA $\varepsilon_r = \frac{C_x}{C_o}$ $\varepsilon_r = 1.0053$ (DRY AIR) RELATIVE PERMITTIVITY

NOTES:

CUSTOMER. P.O. 8396

pf = μμf OR 1.0×10^{-12} FARADS SEP. = SEPARATION OF ELECTRODES
A = AREA OF GUARDED ELECTRODE