



Fermilab

**Particle Physics Division
Mechanical Department Engineering Note**

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Title: IPND Scintillator – Waver Shifter Dissolve Process and
Integration Prototype Detector Scintillator Production.

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On September 27th, 2007, the above listed people met with the author to review the steps and procedures described below.

Key Words: NOvA, Liquid Scintillator, Blending, Mixing, Pseudocumene,
Wave Shifting Dopants

Abstract Summary: See below.

Applicable Codes: None

IPND Scintillator

Wave Shifter Dissolve Process and Integration Prototype Detector Scintillator Production

Dave Pushka - FNAL
September 24, 2007

Six separate steps will be used to dissolve wave shifter powder in pseudocumene prior to diluting the pseudocumene with mineral oil to produce the NOVA liquid scintillator. These steps (at an executive summary level) are:

- 1) Load wave shifter powder in to the blend vessel.
- 2) Purge blend vessel with nitrogen gas to displace oxygen and eliminate fire hazards
- 3) Transfer pseudocumene from 55 gallon drums to the blend vessel.
- 4) Circulate pseudocumene in the blend vessel to fully dissolve the wave shifter powder
- 5) Transfer the pseudocumene and wave shifter blend to the mineral oil tank to produce the liquid scintillator.
- 6) Circulate liquid scintillator to achieve a uniform blend

Equipment used for these steps are:

One blend tank, 347 gallon capacity, 304 stainless steel construction with a 10 inch nominal diameter powder loading hatch, a 2 inch nominal diameter bottom drain, and six top connections (2 @ 1/4" N2 purge in and out; 2 @ 1" pseudocumene liquid in and vent; 2 @ 3/4" liquid in and drum vent). This blend tank is already in hand and is in the process of being cleaned and modified to add the top connections.

One electric powered drum pump with 2 inch bung adapter to transfer the pseudocumene from the delivery drums to the blend tank

One secondary containment vessel to hold the entire contents of the blend tank (this will be made from an existing structural steel weldment)

One variable speed pseudocumene compatible blend pump (in hand)

Source of gaseous nitrogen to purge the bend tank (Dewar ordered from the stock room)

Two pseudocumene compatible liquid transfer hose, 3/4" and 1 1/2 inch nominal sizes

Two pseudocumene compatible vapor transfer hoses, 3/4" and 1 1/2 inch nominal sizes

One Liquid totalizing flow meter (in hand). Scienco Products Model SEM-10S. Wetted materials of construction include stainless steel, Ryton (PPS), Polypropylene. Uses Viton O-rings. This unit is planned to be used in steps 3, 4, and 5.

One liquid totalizing flow meter (in hand). Great Plain Industries Model GM015H2R21-6. Wetted materials of construction include aluminum and Ryton.

One load cell based scale, minimum capacity of 4000 pounds. Sufficient to weigh the 500 pound tare weight blend vessel and the contents of the blend vessel when filled with pseudocumene.

STEP 1; Loading the Wave Shifting Powder

- 1a) Clean Blend Vessel
- 1b) Dry Blend Vessel
- 1c) Mount the blend vessel on the load cells.
- 1d) Weigh the blend vessel to establish a tare weight
- 1e) Open the top port of the blend vessel and lower the appropriate quantity of wave shifting powder into the vessel.
- 1f) Close the top port of the blend vessel

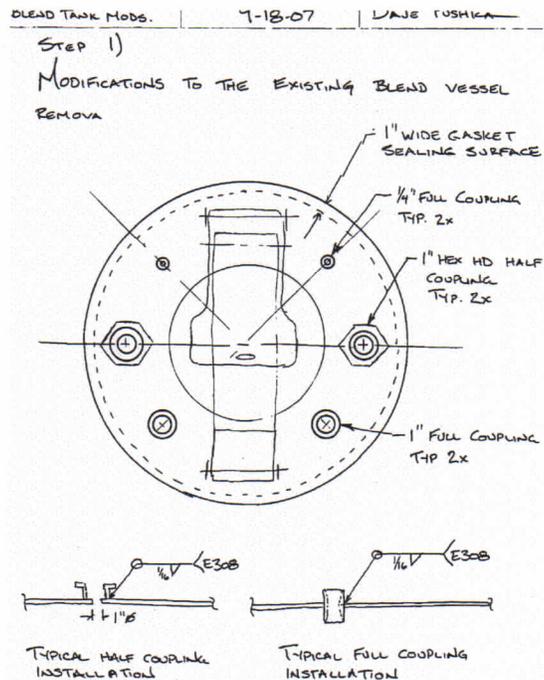


Figure 1, Modifications to the Blend Tank Top Hatch

STEP 2; Purge Blend Vessel to Inert the Atmosphere

- 2a) Connect the gas outlet of a 160 liter nitrogen Dewar to the ¼ inch port with a dip tube (pipe that goes to the bottom of the vessel) located on the top of the vessel.
- 2b) Open a ¼ inch vent port on the top of the vessel and connect to a variable area flow meter to measure the purge rate.
- 2c) Start the flow of GN2, adjust to about 50 scfh
- 2d) Purge for 2 hours to allow for two complete volume changes in this vessel
- 2e) Cease nitrogen purge, disconnect the GN2 fill line. Close valves to isolate the vessel.
- 2f) Weigh the purged blend vessel with the wave shifting powder in it. Record this and use as the tare when loading the pseudocumene.

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STEP 2; PURGE BLEND VESSEL TO INERT ATMOSPHERE

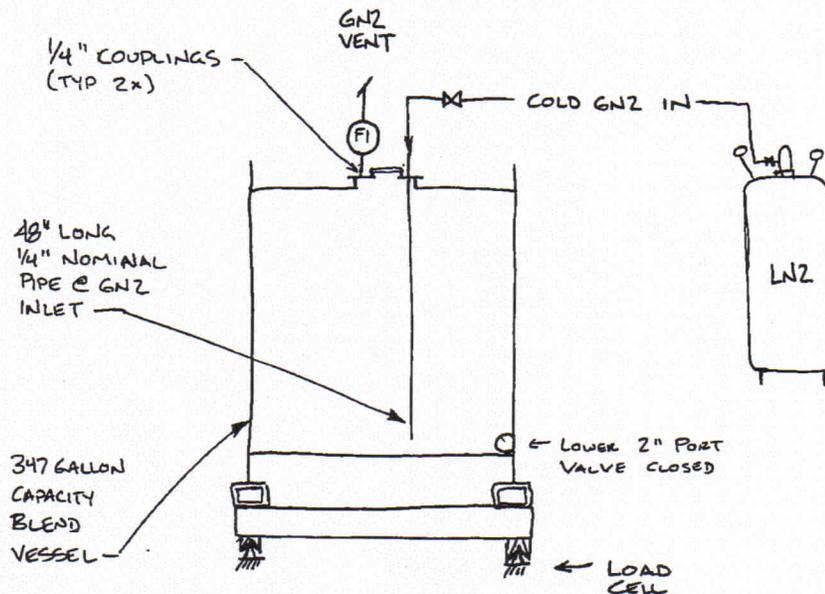
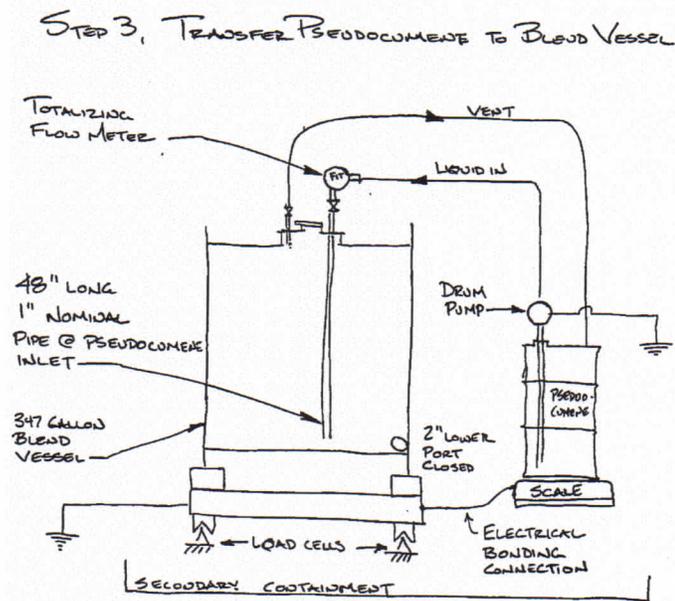


Figure 2, Pipe Schematic for the Blend Tank Purge

STEP 3; Transfer the Pseudocumene into the Blend Vessel.

- 3a) Weigh one filled drum of pseudocumene
- 3b) Insert drum pump into the 2 inch bung hole and screw in hand tight.
- 3c) Connect the $\frac{3}{4}$ inch nominal diameter pseudocumene liquid transfer hose from the drum pump outlet into the liquid totalizing flow meter and zero the flow meter (meter outlet should be mounted to the top of the blend vessel to a 1 inch port).
- 3d) Run a vapor hose from the blend tank to the $\frac{3}{4}$ inch bung hole on the pseudocumene drum to a $\frac{3}{4}$ inch port on the blend vessel. This will eliminate the possibility of worker exposure to vapor and will ensure an inert atmosphere remains above the pseudocumene liquid.
- 3e) Connect a bonding wire from the 55 gallon drum to the blend tank.
- 3f) Start the drum pump. Operate until the pseudocumene drum is empty.
- 3g) Read and record flow meter totalizer display.
- 3h) Disconnect vapor hose and cap hose, replace plug in $\frac{3}{4}$ inch drum bung.
- 3i) Remove drum pump and replace 2 inch drum bung
- 3j) Weigh empty drum and calculate the weight of pseudocumene transferred.
- 3k) Repeat steps 3a thru 3j until the proper amount of pseudocumene has been transferred into the blend tank. Step 3f may have to be modified so as not to fully empty the last pseudocumene drum.
- 3l) Read the blend vessel load cell scale and subtract the weight measured in step 2f to determine the weight of pseudocumene added.
- 3m) Sum the weights measured in steps 3i and compare to the weight in step 3j. Record values and perform error calculations



STEP 4; Circulate Pseudocumene in Blend Vessel.

- 4a) Open 2 inch ball valve at the bottom of the blend vessel to allow liquid to enter the pump suction
- 4b) Energize the variable frequency drive (plug it into the wall)
- 4c) Press the green 'run' button on the variable frequency drive and start the pump.
- 4d) Allow pump to operate for 30 minutes to ensure adequate time for the wave shifting powder to dissolve and achieve a homogeneous blend
- 4e) Press the red 'stop' button on the variable frequency drive.
- 4f) Un-plug the variable frequency drive from the wall outlet
- 4g) Close the 2 inch ball valve at the bottom of the blend vessel.
- 4h) Draw a liquid sample from the pump housing drain port and perform QC/QA testing on it.
- 4i) Weigh the blend vessel and subtract the blend vessel tare weight to establish the weight of pseudocumene and wave shifting powder dissolved in it.

STEP 4; CIRCULATE PSEUDOCUMENE IN BLEND VESSEL

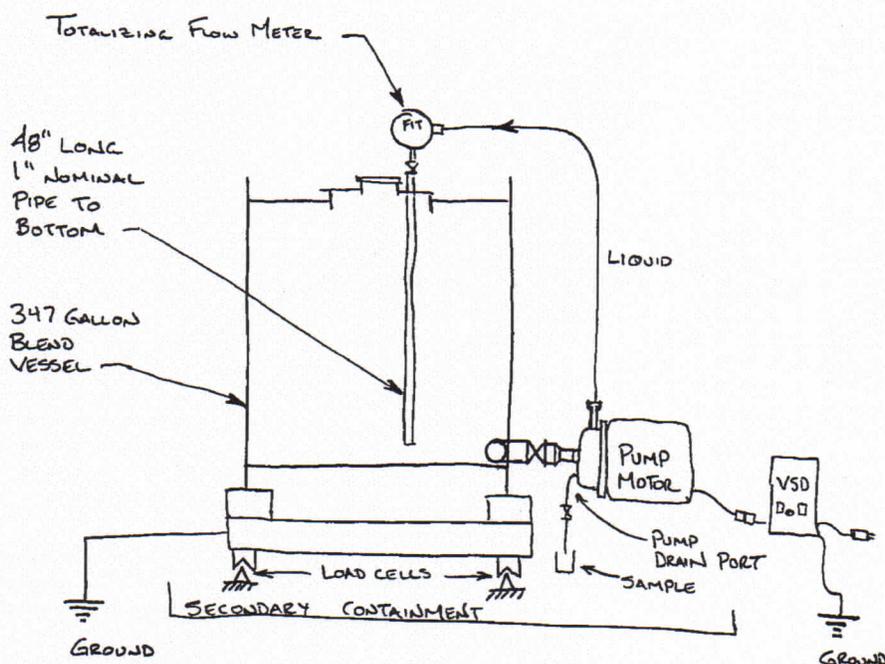


Figure 4, Piping Schematic for the Pseudocumene Circulation

STEP 5; Transfer Pseudocumene from Blend Vessel to Mineral Oil Tank

- 5a) Transport Blend tank filled with pseudocumene to the mineral oil ISO tank.
- 5b) Connect a 1 ½ inch diameter pseudocumene vapor compatible hose from the 1 inch vent on the blend tank to the 1 ½ inch BSP connection of the top of the ISO tank.
- 5c) Open valves on both ends of the hose installed in step 5b to connect the vapor spaces of both tanks
- 5d) Connect a 1 ½ inch pseudocumene compatible hose from the blend pump discharge, thru a totalizing flow meter, to the 3 inch connection at the bottom of the mineral oil ISO tank. Zero the flow meter.
- 5e) Connect a bonding connection between the ISO tank and the blend tank.
- 5f) Open the two inch ball valve on the blend tank to allow pseudocumene into the blend pump
- 5g) Energizer the variable frequency drive (plug it into the generator)
- 5h) Press the green 'run' button on the variable frequency drive and start the pump
- 5i) Open the 3 inch butterfly valve and the internal ISO tank valve to allow pseudocumene to enter the ISO tank bottom port
- 5j) Operate pump until the pseudocumene blend tank is empty.
- 5k) Read and record the value of transferred pseudocumene from the totalizing flow meter.
- 5l) Close 3 inch butterfly valve and the internal ISO tank valve at the ISO tank bottom port.
- 5m) Press the red 'stop' button on the variable frequency drive.
- 5n) Un-plug the variable frequency drive from the generator
- 5o) Close the valves on each end of the 1 ½ inch vapor hose
- 5p) Disconnect the ¾ inch pseudocumene transfer hose from the ISO tank bottom port. Collect any pseudocumene remaining in the hose. Disconnect the bond wire.
- 5q) Weigh the pseudocumene blend tank. Subtract from the weight measured in step 4i to determine the weight of pseudocumene and dissolved wave shifter powder added to the mineral oil.

Step 6; Circulate Liquid Scintillator to Achieve a Uniform Blend.

- 6a) Connect suction side of the blend pump with to the 3 inch bottom port of the ISO tank with a short length of 1 ½ inch pseudocumene compatible hose

- 6b) Connect the discharge of the blend pump to the to the 1 ½ inch connection at the top of the ISO tank.
- 6c) Open the ISO tank top valve
- 6d) Open the ISO tank bottom butterfly valve and the internal tank valve
- 6e) Energizer the variable frequency drive (plug it into the generator)
- 6f) Press the green 'run' button on the variable frequency drive and start the pump.
- 6g) Operate the blend pump for 4 hours.
- 6h) Draw a sample of the liquid scintillator and perform QA/QC measurements.
- 6i) Close 3 inch butterfly valve and the internal ISO tank valve at the ISO tank bottom port.
- 6j) Press the red 'stop' button on the variable frequency drive.
- 6k) Un-plug the variable frequency drive from the generator
- 6l) Close the top ISO tank valve
- 6m) Disconnect the blend pump discharge hose and collect any liquid remaining in the hose
- 6n) Disconnect the blend pump suction hose and collect any liquid in the hose.