BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION OF NAVIGATOR HEARTLAND GREENWAY, LLC FOR A PERMIT UNDER THE SOUTH DAKOTA ENERGY CONVERSION AND TRANSMISSION FACILITIES ACT TO CONSTRUCT THE HEARTLAND GREENWAY PIPELINE IN SOUTH DAKOTA	**HP22-002** **CURTIS JUNDT** **INITIAL PRE-FILED TESTIMONY IN SUPPORT OF LANDOWNER INTERVENORS**

Q: Mr. Jundt, can you tell the Commissioners a little bit about your educational background and work background?

A: 41 years I graduated from NDSU with my engineering degree and prior to that for about four years, five years all going through school I worked for three different consulting engineering firms out on construction inspection putting in water lines and sewer lines across Fargo and in the Burley County, Bismarck area, but I left NDSU with my engineering degree, decided I did not want to be a consultant so I did get a job, took me back to Bismarck working for the MDU Resources corporation which I spent 15 years there much of it was in the pipeline business. I actually was the guy that you would go to if you wanted to build to or from the interstate pipeline. My last three or four years there I was director of WBI gas services, and I oversaw the development of shallow gas fields, drilled about a hundred and eighteen shallow gas wells, fracked the dickens out of them and built all the gathering systems and booster stations, I oversaw it I was basically the project guy.

Q: Did you come from an engineering family?

A: I sure do.

Q: Who was your father?

A: Ray Jundt, he was city engineer of Bismarck until for about 34 years until he retired in April of 93.

Q: And have you been involved in terms of engineering and building energy pipelines before?

A: I have.

Q: Okay, have you been involved in building compressor stations for any energy pipelines?

A: I was part of being more or less the project manager I had a good team of engineers but yes, the Glen Olin station injecting into the 42-inch northern border pipeline, the extension from Valley City to Mapleton which involved compression but numerous projects.

Q: And have you been involved in uh building and overseeing projects involving energy shutoff valves?

A: Of course, that's all part of the operation maintenance, safety, control of a natural gas pipeline.

Q: And you also have experience with the operation of energy pipelines for gases other than CO2?

A: Natural gas that's the world I come from, so very passionate about it, so yes.

Q: And do you have experience dealing with safety issues relating to energy pipelines?

A: Yes, most of the 15 years of my corporate career I was actually on the Corporate Safety Committee representing the headquarters in Bismarck and we would hold our meetings in Glendive and I even did Hazmat training so safety even in my private businesses that I retired from seven years ago I did have a safety services company, it's a very big part of my world.

Q: And as part of your work experience in with energy pipelines and also your engineering training do you have knowledge and education and experience with carbon dioxide with CO2?

A: I do not.

Q: Do you know whether or not there's a difference between natural gas and CO2?

A: Yes, I do okay.

Q: And what is the difference?

A: Well, I believe the differences are very stark. Natural gas goes up and I know it's all about the thermal physical properties of natural gas versus CO2 and the laws of gravity methane which is a predominantly 96 percent of our natural gas stream with other hydrocarbons that's about 0.55 to 0.65 specific gravity and when that ruptures it goes up until it dissipates in the air you know you could have a spark that could set it off where CO2 is 1.55 so 1.55 times heavier than ambient air and that will once it sublimes from its solid particles and ice crystals it will warm up and become a gas and move low to the ground in low-lying areas there's a very significant difference CO2 is not combustible but it moves across pretty good distances and low-lying areas like fog and depending on the breeze the temperature increasing the density and the colder it is like this winter we had days where it was 25 below zero and more, that cloud will stay dense and take longer to dissipate if we have 10 to 15 mile an hour winds which we can get whereas natural gas is different it goes up and if it does ignite we're talking about a an event that is localized to where the rupture is, there's significant differences.

Q: Let's talk about size and pressure of pipelines and so you have studied the Navigator Pipeline application and their engineering information?

A: Generally, yes. Like any pipeline system you've got your gathering lines which I would call those the lines coming from the ethanol plants or laterals and then they move to maybe a several will come into a trunkline, so you'll maybe have four inch then you'll move to maybe a six or eight inch and it's all about volume until you finally interconnect with the main line.

Q: So, what's the difference going to be in terms of the volume of CO2 that will be in a 4 inch pipeline versus a 24 inch main line?

A: So early on as my awareness, I gained an awareness about this project, that was a question that was asked of me almost right away what's the difference between an eight inch you know we're talking about Denbury running from DGC up to the Weyburn field is eight and twelve what's the difference between that eight inch and a 24 inches at three is this 24-inch going to carry three times more? And I said no just the difference of squares without friction losses this 24 inch will be equivalent to 9.4 8-inch pipes but when you factor in friction loss you're talking about fifteen 8 inch pipes to move about the same volume as this one will at you know 2183 PSI it's significantly different.

Q: Okay and so you would need fifteen 8-inch pipelines to carry the same amount of CO2 that can be carried in a 24-inch pipeline?

A: That's my opinion yes.

Q: And then what significance does it have that that this pipeline is a is planned to be a critical pressure pipeline at 2183 pounds per square inch?

A: So, I'm very familiar with high pressure pipelines to reach supercritical phase CO2 has to reach 1070 PSI at 87 degrees. Now there are going to be points along this pipeline where the temperature is probably not going to be 87 degrees the further the CO2 gets away from the discharge end of a compressor station. So, you know it could be less than that but when you're well above 1070 PSI you're going to remain in supercritical state phase across a pretty good temperature range.

Q: So, when this pipeline is planned to be supercritical is that extremely high pressure?

A: It is you know near well 2183 maximum allowable operating pressure starting out depending on how full the pipe is they may not be at that right away but from what I've heard they intend to you know like any pipeline you intend to maximize your throughput so we have to expect sooner than later they will get it to be running this at 2183 PSI.

Q: And so, let's talk about a 24 inch pipeline from a shutdown standpoint how that would happen if there was a leak what would that shutdown process look like?

A: Well again I can only relate from the natural gas industry and we aren't talking about a totally different we're talking about a baboon and a monkey here but this is a baboon so if this thing's running it's super critical at maximum pressure, you don't get a lot of wiggle room in shutdown procedures if you're running a natural gas pipeline at 400 PSI but the allowable pressure in the pipe is 800, you can probably shut your valves quicker because you know things you have 400 PSI to pressure up so this in my opinion will have to be an orderly shutdown to prevent a water hammer like effect and catastrophic failure downstream of any rupture, so the upstream valve could shut pretty darn quick like immediately. I don't believe, the valve can shut in the actuator can close the valve in two minutes I don't believe that that's going to be two minutes from the time they sense a pressure drop there there's going to be an orderly shutdown and I know there's pressure sensors and pop-offs on other compressor stations and all the safety stuff but there's going to be I don't know is it going to be tens of minutes is it going to be 30 minutes before that downstream valve is shut. I don't believe it's going to be just minutes and so what is this this uh did you call it a water hammer effect correct what's the water hammer effect well you know you're running this at a super critical fluid and it's really not the pure fluid liquid CO2 and it's not the gas it's right in between those

two phases it's very dense um Wayne you know having a weight in the pipeline that and you're going to be at 2183 PSI it's going to be you know potentially 50 pounds per cubic foot in that pipe at 2100 PSI and if it's running at maximum allowable pressure the nearest compressor would have to shut down immediately so once that shuts down then and stops discharging they can shut the downstream valve of beyond the rupture so maybe minutes is not unreasonable depending on the response. There's going to be humans involved in this the equipment's not going to automatically shut stuff down, there will be humans involved in evaluating the data.

Q: Okay so where will there be a lag time between when whomever at Navigator is monitoring the line sees a drop in pressure to win, they can start the shutdown process?

A: There is lag time, shutoff is not instantaneous.

Q: Okay and what does that lag time range to and from?

A: It depends on the circumstance, it the amount of pressure drop, location, you know you if it's a small pressure drop it could be a faulty pressure sensor they would send a fuel guy out to verify so it one size doesn't fit all in any of this

Q: In terms of pipeline you understand this is a carbon steel pipeline that Navigator proposes to install is that correct?

A: Correct.

Q: Okay and is that type of carbon steel pipeline CO2 pipeline does it have the same susceptibility to corrosion that a natural gas pipeline does

A: It does

Q: Okay and so can you explain that.

A: So natural gas we limit four pounds per million cubic foot of water we let in minimal grains of H2S 0.4 percent of CO2. CO2 and H2S are extremely corrosive especially if there's any water vapor content in the pipeline at all but the biggest thing with water content in the natural gas pipeline isn't, it's not the when water vapor mixes with methane CH4, it's not in and of itself corrosive we do we minimize that for yes corrosion but we want to minimize it so that when you do pressure drops across the system into town borders and across valve settings that's an endothermic reaction we don't have hydrates so that's why we limit other liquid hydrocarbons too to prevent valves and things like that from freezing up.

Q: So is CO2 from carbon capture likely to have some water in it?

A: Well that's one of the byproducts of natural gas combustion that's another is water vapor and they'll have to dehydrate after capture at every ethanol plant

Q: So if there's some water vapor in the CO2 that goes in the pipeline will that increase the risk of corrosion of the pipeline?

A: Correct just like you know they don't have to deal with H2S which is a good thing, but they're going to have to be extremely vigilant and I believe even more than natural gas, because of the fact that any water vapor, any water in that pipeline with CO2 forms that carbonic acid and it can corrode through the pipe very quickly. They'll have to dehydrate this CO2 you know drier than a popcorn fart, I mean it's going to have to be very dry and I'm sure that's what they're going to do but that's another critical thing that has to be monitored because that carbonic acid can do significant damage to even a weld, I mean your weakest length are your welds, so the internal corrosion on the internal part of a weld is a big risk.

Q: Do CO2 pipelines operate at higher pressure than natural gas pipelines?

A: Well not necessarily I mean in my experience the higher pressure higher highest pressure one I believe I've had any experience with is Northern border and that runs at 1440, and maybe higher I think they did a pressure upgrade it might be up to 18 inches, it might be close to 2000 by now but that would be probably the highest one I'm aware of.

Q: Navigator says that a CO2 pipeline is as safe as or safer than natural gas pipelines from an engineering perspective do you believe that to be true?

A: Absolutely not.

Q: And why not?

A: We're talking about a monkey and a baboon here - they may look similar but that are not the same. I would prefer that the CO2 were combustible. I would prefer that it was the specific gravity of methane or even anhydrous ammonia which has a specific gravity of 0.767 I think, because it's going to tend to disperse upward and out much faster, you know we have significant experience with natural gas we odorize it when they built the first long-haul hundred some mile natural gas pipeline in 130 years ago they didn't odorize it but you know like all things in engineering pretty much we learn and grow from you know catastrophic or bad incidences so then that came into play years later and we odorize natural gas that's

a significant safety aspect and a significant difference between CO2 and natural gas we have something that you can smell even a very small leak anywhere around your home or in your home and most, and so 130 years of natural gas versus, and three million miles of pipe and natural gas systems versus 5150 total miles, I mean there's, we're talking two different animals here from a safety standpoint and public awareness.

Q: And then in terms of anything that would alert someone there's been a CO2 leak will there be any color any odor, any plume that would show a color in the plume?

A: No.

Q: Is there going to be any warning to the public or someone nearby in the event there's a CO2 leak in in terms of odor or color or something like you might have with natural gas where you can smell

A: No there won't be you will just hear the jet noise of the rupture.

Q: Okay and so um in terms of comparing natural gas versus CO2 in terms of what would happen in the leak event is one more lethal or potentially lethal than the other?

A: I believe CO2 is substantially more lethal.

Q: So based on the thermal physical properties of CO2 let's talk about what would happen if a leak occurred based on the physical thermophysical properties of CO2 what would happen if that leak occurred?

A: Okay so this is where appropriate plume modeling is going to be extremely complex and it is extremely complex because of all the variables but I can envision knowing enough about the thermal physical properties of natural gas versus propane butane and CO2, in a CO2 in a pure form 98 supercritical when that erupts it's going to be a guillotine break. A guillotine break is when the pipe separates at a weld could you have the full diameter of the pipe venting at that point versus just a crack or a pinhole so in a guillotine break in a 24 inch pipe this is going to blow a crater in a hole it's very substantial the temperature will drop to minus 109 and colder, it'll shoot solid particles of CO2 up in the air it'll crystallize any water vapor in the air and when that finally warms up it'll flow to the ground.

This pipeline cannot be located anywhere near a residence or active business – to suggest 500 feet or anything close to that is an appropriate setback is irresponsible.

Q: And these have you seen anything to suggest that Navigator is proposing to have CO2 sensors placed in the community

A: No.

Q: Near this pipeline?

A: No.

Q: And would those in your opinion be mandatory to alert the public in the event of a leak?

A: Yes. There are many safety and alert mechanisms that should be considered.

Q: And I just want to ask about some pipeline ductility issues um so have you studied the information um in regards to whether or not there's any information showing whether the pipe materials will meet specific ductility requirements?

Q: This idea of a monitoring system that you talked about I think you said it's an idea

A: It’s an idea.

Q: To give people notice right?

A: Early notice early warning.

Q: You talked about the potential for corrosion inside of the pipeline and II think there what I heard you say was they just have to be very careful to make sure that they don't introduce too much water content into the pipe right?

A: Dehydration will be even more critical than any natural gas line correct.

Q: Would you agree that the closer the mainline valves in more populated areas of South Dakota, the better?

A: Yes, it's all about mitigation, the further away the less you've vent, so yes I would agree.

Q: Do you have an opinion then on if there's an is there a greater propensity for issues with the line being above ground say a thousand feet and thousand feet increments with mainline valves than if it was remained underground with mainline valves at a greater distance?

A: It’s somewhat of a catch-22 because valve settings, welds compressor stations, dehydration facilities are where you are most susceptible to have a leak or an escape so the more above ground valve settings we have, there's going to be more maintenance required. But again, I think the safety that it brings nearby residents far outweighs other considerations.

Q: How long we could expect if there's a full-bore guillotine break on a 24 inch line in your opinion how long would it blow gas for a 10 miles versus a 20 miles spacing of block valves?

A: I don't think it's linear but it's probably going to be, it's not probably going to be twice as long but it's probably going to be 1.8 or times as long because that higher pressure is going to move that product out really fast and then it'll decline but till it stops venting that's when it reaches equilibrium with atmospheric pressure and the same with the natural gas so until that flame on that gas went down and it actually just snuffed itself out, it you know it was actually at or below atmospheric pressure when it stopped so. But I would say look at what Chief Briggs of Satartia, Mississippi has said about that CO2 pipe vented for several hours 9.5 miles that was 1402 PSI when it ruptured. Now we're talking about 20 miles of potentially at some point and I know that as a pipeline company you want to get there sooner and later fill your pipe, so 2183 PSI we're talking substantially longer hours and we're talking about CO2 you know 10 to 20 mile an hour winds could cover a significant area in miles length and width. So, at different concentrations and you know four percent and higher is a problem and we breathe 0.03 to 0.05 and OSHA says you can eight hours you can be exposed to .5 percent .5, so for many many thousands of feet from a 24-inch Guillotine rupture we're going to be much higher probably than four percent.

/s/ Curtis Jundt

Curtis Jundt