Technical Reviewers' Rating Summary and Applicant's Comments

Proposal Number: G-39-02
Application Title: New Technologies for Safe and Cost Effective Oil Conditioning in North Dakota
Submitted By: Statoil
Request For: $200,000.00
Total Project Costs: $400,000.00

Section A. Scoring

Statement	**Weighting Factor**	**G-39-02A**	**G-39-02B**	**G-39-02C**	**Average Weighted Score**
1. Objectives	9	**4**	**3**	**3**	**27**
2. Achievability	7	**4**	**3**	**4**	**21**
3. Methodology	8	**3**	**2**	**3**	**16**
4. Contribution	8	**4**	**4**	**3**	**24**
5. Awareness / Background	5	**3**	**3**	**2**	**10**
6. Project Management	3	**2**	**2**	**2**	**6**
7. Equipment / Facilities	2	**3**	**2**	**3**	**4**
8. Value / Industry - Budget	4	**3**	**2**	**3**	**8**
9. Financial Match - Budget	4	**3**	**3**	**3**	**12**
Average Weighted Score		**171**	**141**	**149**	**153**
	Total: 50				**250 possible points**
OVERALL RECOMMENDATION					
FUND		**X**			
FUNDING TO BE CONSIDERED			**X**	**X**	
DO NOT FUND					

Section B. Ratings and Comments

1. **The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are:**

   "The objectives of this project are clearly spelled out in the objectives section. They are to develop a model of typical oil conditioning of a Bakken crude oil and then test sonic separation or chemical separation to meet RVP spec of 13.7 psi without using any more heat than necessary. This will allow maximum value of the crude oil product to the Producer. "
   - Reviewer: G-30-02A
   - Rating: 4

   "Clearly stated objective to identify "technology solutions that can be implemented" to improve compliance with crude oil conditioning order 25417. "
   - Reviewer: G-39-02B
   - Rating: 3

   No comment
   - Reviewer: G-39-02C
   - Rating: 3

   Applicant Comments:
   No comment from applicant.

2. **With the approach suggested and time and budget available, the objectives are:**

"They certainly are obtainable for a Phase I consideration as most of the work is in a lab or Hysis computer system modeling. The chemical evaluation may take some field testing, but six months to complete the work with a year for published results is very realistic. "
- Reviewer: G-30-02A
- Rating: 4

"Project scope does not include much detail regarding tasks to be performed. Budget seems larger than necessary based on information provided. "
- Reviewer: G-39-02B
- Rating: 3

"This proposal contains 2 methods, one for ultrasonic separation and one for chemical separation. The chemical separation is not well defined and almost seems to be an after thought. I would prefer to see this dropped from the proposal. Major chemical companies can do their own research or submit a proposal. "
- Reviewer: G-39-02C
- Rating: 4

Applicant's Comments:
We do agree that the proposal does not provide a significant amount of detail regarding project tasks. This was intentional to leave some options open for discovery. However, in the interest for clarification please consider the following details:

Task 1 – The project team will model the evolution of light ends from the well head to tank storage. The purpose is to gain a greater understanding of the expected vapor pressures throughout the oil conditioning process at the wellhead and identify the mechanism behind the RVP challenge. Based on results, we may be able to identify some unique opportunities for technology to remove additional light ends based on the expected concentrations of light ends. Additionally, there are currently issues involving ambient temperatures and storage. The team would like to better

understand the nature of light ends that may condense and cause an increase in vapor pressure. Understanding the quantification surrounding these mechanisms may elucidate simple solutions.

Task 2 – An experimental apparatus is proposed to better understand the application of sonic technology in separating gas from crude oil. Equipment is readily available off-the-shelf for flow through experiments, and a number of qualified labs have the capability to sample and conduct gas analysis and light ends analysis. We will hire the most qualified laboratory. We expect to develop a test matrix that will provide operational data at various temperatures, acoustic settings and residence times. The project team will subcontract to a laboratory to fully instrument, conduct sampling, and analyze results. This activity is expected to cost on the order of $100,000. Our team will be instrumental in designing the experiments, and ultimately measuring the RVP performance. We plan to use Grabner instruments following ASTM method D6377 to measure RVP. The experimental apparatus will be instrumented for temperature and pressure and to provide a complete mass balance.

Task 3 – We have identified a number of services that can gel hydrocarbons which will reduce RVP. Hydraulic fracturing is the most common service in which gelling of crude can be accomplished with a phosphate-ester gel. However this task involves customizing the chemical for the purpose of reducing the vapor pressure, and determining if the service can be economically applied in the field. No single chemical company has the capability of solving the problem from an operational viewpoint, and the project team is needed to provide the guidance to ultimately develop a service that our industry can use economically. We expect to measure the RVP of crude samples before and after chemical treatment to determine performance, and minimize the amount of chemical. Based on servicing and chemical costs; we will also design and determine a means to treat volumes of high RVP crude in the field from individual tanks, to in-line treatment. Ultimately we will determine the downstream saleable impacts and chemical limitations.

3. The quality of the methodology displayed in the proposal is:

"The methodology is sound. Hysis is a widely used tool in the oil and gas industry so the modeling should be easily accomplished and a match made to existing conditions. The lab work for the sonic testing should yield interesting results that can be field tested in Phase II. The chemical testing may be a combination of lab and field testing and may be the most involved in Phase I. Selection of the Vendors for Phase I &II is addressed appropriately."

- Reviewer: G-30-02A
- Rating: 3

"The tasks proposed are appropriate, but detail is lacking that could substantiate or support the likelihood activities will have the intended result."
- Reviewer: G-39-02B
- Rating: 2

"I am concerned that their model only tests at atmospheric conditions. The proposals states "wellhead" separation, however, their bench scale test shows crude oil being drawn from a pre-mix tank that is at atmospheric conditions. To replicate this in the field will require a vapor recovery unit (VRU) if the process is conducted at atmospheric conditions. The use of a VRU will, in and of itself reduce the RVP. I would prefer to see this experiment conducted under conditions that simulate treater or pressure vessel conditions at or near pipeline pressure so that the liberated gas can be sent directly to the gas sales line without additional expensive, high maintainance equipment. I suspect, however, that ultrasonic liberation of entrained gasses under pressure will not be viable. "
- Reviewer: G-39-02C
- Rating: 3

Applicant's Comments:
Please see added detail under comments for question 2.

Most of our well-pad locations use a two-phase separator, and heater treater arrangement. The two-phase separator is operated at pipeline pressure to push gas to sales (~100 psi). Few of our locations include VRUs. The project team will model the conditions at the operating pressures and temperatures of the well head separation equipment. Yes, the laboratory equipment is to be operated near ambient pressure; however we are also operating our treaters at relatively low pressures. The NDIC limits the operating pressure of treaters to no greater than 50 psi.

4. **The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be:**

"Having the modeling results of conditioning Bakken crude to meet the RVP spec of 13.7 psi year around available to others is an advantage to all Producers of Bakken crude. Also, testing a couple of methods (sonic & chemical) to potentially enhance the process without reducing the volume of crude oil any more than necessary is also of advantage to everyone involved. I believe these are timely and useful tools to help the State and Producers enhance production methods and also meet the goals of increased Safety in shipping Bakken crude in the State of ND. "
- Reviewer: G-30-02A
- Rating: 4

"Additional tools are needed to cost effectively improve crude oil volatility. Identification of alternative ways to reduce vapor pressure could have significant impacts on the industry. "
- Reviewer: G-39-02B
- Rating: 4

"The additional cost associated with oil conditioning is significant and will result in a loss of oil and gas reserves since the economic limit of Bakken Petroleum System wells will be reached earlier due to the increased operating cost. "
- Reviewer: G-39-02C
- Rating: 3

Applicant's Comments:
Many of the approaches we have encountered to comply with recent RVP requirements involve centralized stabilization, or significant equipment adds to the wellhead. Although robust, such efforts add significant cost and complexity. The intent for this work is to develop simple solutions that improve performance specifically geared towards reliability, and addressing issues surrounding field operations that can be implemented across the basin. For instance, if a technology can bolt-on to an existing treater, both operational reliability and a cost advantage can be achieved simultaneously.

5. **The background of the principal investigator and the awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is:**

"The principal investigator has good background in industry and also formerly with a research group. He also has a patent and has published many articles. "
- Reviewer: G-30-02A
- Rating: 3

"The proposal author refers to RVP repeatedly. Data provided by Lord et al, referenced by the proposal author indicate that TVP and not RVP is the appropriate metric for assessing crude oil volatility. "
- Reviewer: G-39-02B
- Rating: 3

"The literature referenced contains few papers that have been published in referreed journals. I am not sure if this is due to the lack of study in this area. A brief search on the internet yielded several papers on ultrasonic removal of Sulfur in crude oil. A cursory review of these papers indicate that the process may be transferrable. "
- Reviewer: G-39-02C
- Rating: 2

Applicant's Comments:
We are breaking new ground by looking at a sonic technology. There is little understanding for how this technology will perform relative to separation of gas from crude oil, and our problem in North Dakota is unique to the recent order. There are a reasonable number of resources providing fundamentals in sonochemistry, we are currently involved in literature review in this area to enhance our understanding.

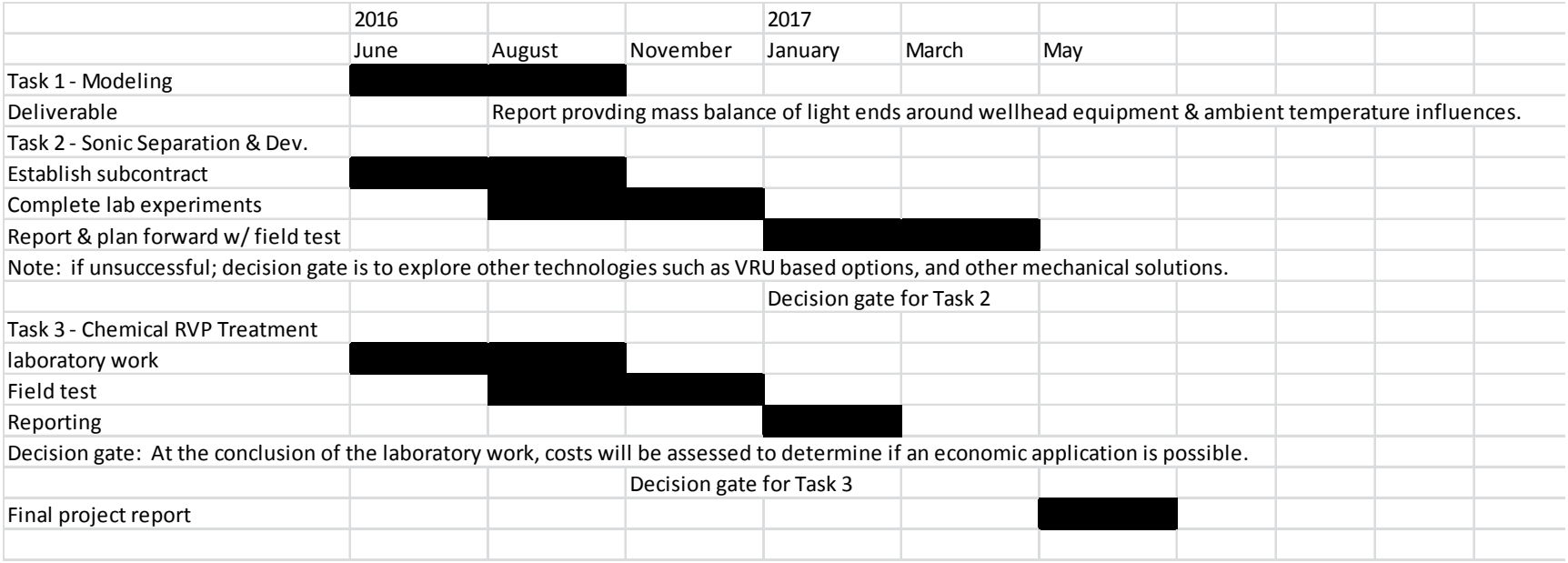
6. **The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is:**

"I would have liked to see more a defined timetable with results and goals. What is supplied is pretty limited, but it is only a first Phase and mostly research work at this time. I think a better definition could be provided."
- Reviewer: G-30-02A
- Rating: 2

"Identification of go, no-go decisions within tasks, or milestones within each task would improve the management plan and assure the reviewer that state resources are being used efficiently. "
- Reviewer: G-39-02B
- Rating: 2

"I would have preferred to see a better timetable for deliverables."
- Reviewer: G-39-02C
- Rating: 2

Applicant's Comments:
See chart below



7. The proposed purchase of equipment and the facilities available is:

"Laboratory equipment of less than $10,000 is really the only equipment expected to be purchased in this first phase, so it is pretty minimal. "
- Reviewer: G-30-02A
- Rating: 3

"It is unclear if equipment purchase is necessary or if the service could be contracted. If initial trials suggest the use of sonic separation equipment is ineffective, equipment purchase would not be warranted and work could be done to pursue other methods of reducing vapor pressure.
- Reviewer: G-39-02B
- Rating: 2

No comment
- Reviewer: G-39-02C
- Rating: 3

Applicant's Comments:
Most labs do not have flow-through sonication equipment on hand. We are expecting to purchase the equipment through the subcontract, and expect the laboratory to instrument and operate. The equipment is off-the-shelf.

8. The proposed budget "value"1 relative to the outlined work and the commitment from other sources is of:

"The budget is pretty minimal as it is mostly office or lab work with some indirect costs and a little set aside for the lab equipment needed. There is adequate commitment from others and the value of the project compared to what will be spent is very reasonable."
- Reviewer: G-30-02A
- Rating: 3

"Based on available task detail provided in the proposal, the project costs seem high."
- Reviewer: G-39-02B
- Rating: 2

No comment
- Reviewer: G-39-02C
- Rating: 3

Applicant's Comments:
Please refer to the response to Question # 6, and the project plan.

9. **The "financial commitment"2 from other sources in terms of "match funding" have been identified:**

"The support from others is 50% which is the minimum required."
Reviewer: G-30-02A
Rating: 3

"The proposed 50% match is the minimum required by NDIC."
Reviewer: G-39-02B
Rating: 3

"Would prefer a little more detail on the "Subcontract" portion."
Reviewer: G-39-02C
Rating: 3

Applicant's Comments:
We did not previously engage subcontract proposals. The authors are familiar with the expected magnitude of the laboratory work and typical costs. Our team will select the best candidate to perform the work.

1 "value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar. A commitment of support from industry partners equates to a higher value.

2 “financial commitment” from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application; industry partnerships equates to increased favorability.

General Comments:

“I believe this is a good and timely project. With one winter of operational data to meet the newly required spec of 13.7 psi, it is timely to look at methods that could enhance the oil conditioning process other than just using increased temperatures to affect separation of crude products. The chemical study will be interesting as any time chemicals are used, they change or add something to the product, which may perform the task necessary, but also has to be acceptable to the product that is left. Particularly when that product goes to sales from that point it needs to be determined if it is acceptable to the purchaser. This project has a potential large benefit to the industry and is a timely project.”
- Reviewer: G-30-02A

“The proposed work could identify improved methods for reducing crude oil volatility and address an important challenge in ND. In general, a more detailed scope, substantiation of why the proposed tasks are believed to address the challenge, and a more detailed scope would improve the proposal.”
- Reviewer: G-39-02B

“As stated before, I would prefer that the chemical RVP reduction be eliminated from this proposal and re-submitted if able to stand on its own merits. This is a huge problem for the industry and will continue to be one until all rail shipments of crude oil cease in ND. However, removal of gasous hydrocarbons from the liquid stream cause increased greenhouse gas emissions, unless captured and sold into the gas sales line. I would ask them to strip out the chemical portion and focus on the ultrasonic portion, better define the timing of the deliverables e.g. Project start + 1 month = delivery of equipment, etc.

- ***Reviewer: G-39-02C***

Applicant’s Comments:
Our research team and asset team is fully engaged to find field solutions to improving our ability to produce crude oil meeting new RVP requirements. The biggest challenges include operation of existing heater-treaters, and what to do when there are

large amounts of off-spec crude oil in our system. Technologies that can be implemented at the wellhead are most likely to combat the problems associated with production, and have the highest likelihood for being economic. We have selected sonic technology based on supplier conversations, and believe it is worth the partnership with the NDOGRP because of the potential upside if successful. The project team considers the potential for chemical treatment to be a reasonable solution for treating volumes of high RVP crude that may be present within our system. As a basis, current operations chemically treat crude in our pipeline system. The need however is for a flexible and economic chemical service to work across our operations in which we intend to guide the development. The proposed work is specifically focused on the tasks within that appear to have the highest reward; however our team is remaining open to other potential solutions as we move forward.