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## Floating Production, Storage, and Offloading Systems in the Gulf of Mexico OCS: A Regulatory Perspective

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### Abstract

Floating Production, Storage, and Offloading (FPSO) systems represent an untested technology in the U.S. Gulf of Mexico (GOM) Outer Continental Shelf. The reemergence of the GOM as one of the principal offshore oil and gas basins in the world has brought the challenge of integrating new technology into the business of developing the deepwater discoveries. One of those technologies is the FPSO. The U.S. Minerals Management Service (MMS) has been investigating FPSO technologies by participating in discussions with the industry, both domestic and international. The goal has been to understand how an FPSO-based development will be addressed within the existing OCS regulatory structure, and to determine what supplemental efforts might be necessary.

This paper will address the role of industry-accepted practices, worldwide experience, and international efforts directed at the development of safety guidelines in the regulatory review process. It will also discuss the role that risk assessment methodology might play in the regulatory process to help MMS better understand the risks associated with FPSO's and to identify what might be done to minimize the risk levels. The intent of this paper is to give an overview of the regulatory process for a GOM-based FPSO project; it will also be an overview of the MMS Deepwater Operations Plan process.

### Introduction

The possibility of FPSO systems in the Gulf of Mexico has been discussed extensively throughout industry for the past two years; MMS has participated in many of these discussions. According to information compiled and maintained by Bluewater Offshore (posted on their website), there are approximately 50 FPSO's worldwide — located in the North Sea; Indonesia; West Africa; and Brazil.<sup>1</sup> Industry is actively pursuing FPSO systems as a

development strategy for the Gulf, although no one has yet submitted a development application for such.

Prior to the mid-1990's, the use of an FPSO in the GOM seemed to be unlikely given the infrastructure already available and an apparent preference to use fixed platform technology to develop discovered oil and gas reserves. During that time the GOM could be characterized as a mature oil and gas basin; in fact, some considered the GOM to show little promise for significant new discoveries. A renewed interest in the GOM resulted with the technical and economic successes achieved in deepwater.<sup>2, 3, 4</sup> With this move into deepwater, MMS found industry searching for alternatives to the conventional GOM development strategies. The result has been the installation of six tension leg platforms, two spars, a semisubmersible-based floating production system, and numerous subsea developments. More of the same are in the construction phase. Several other recent discoveries in the GOM have been discussed as likely candidates for FPSO-based development.

A paper presented at the 1998 Offshore Technology Conference outlined the major initiatives that MMS has undertaken to address FPSO issues.<sup>5</sup> This year's paper is designed to update and expand on the discussions of regulating FPSO operations in the GOM Outer Continental Shelf, with an emphasis on how the Deepwater Operations Plan (DWOP) process will be used in the review.

One major development since the 1998 OTC is the initiation of an environmental impact statement (EIS) for a generic FPSO in the GOM. The MMS determined that an EIS would likely be required for the first FPSO-based development project on the Gulf of Mexico OCS. Several considerations, including the potential for environmental impacts, the degree of uncertainty about the significance of potential impacts, and the level of concern or controversy associated with a proposed action led to the decision to prepare an EIS. Recognizing the fact that time for completing an EIS is a key aspect for a project, DeepStar agreed to fund the preparation of an EIS for a generic FPSO in the GOM. The environmental impact statement is being prepared under an MMS contract with the objectives to identify potential impacts of FPSO operations, to ensure that FPSO activities conducted in deepwater areas of the Western and Central Planning Areas of the Gulf of Mexico OCS occur in a technically safe and environmentally sound manner, and to serve as a summary National Environmental Policy Act document that will support the required assessments of FPSO's and associated support activities. The projected schedule

shows completion of the EIS in late 2000.

### Regulating FPSO's in the GOM

A multi-leveled review process provides MMS with the basis to determine if a Gulf of Mexico OCS development system can be installed and operated safely and without pollution. The regulatory requirements are established in 30 CFR 250 and include a sequential review of plans outlining the project scope, timing and environmental implications; and design, installation, and operation of an oil and gas development system.

As with other deepwater initiatives, MMS has found itself needing to adapt some areas of the regulatory program and responsibilities to address the different issues and concerns related to FPSO systems. The DWOP is intended to address MMS's review of all deepwater development projects from a total system perspective without writing new regulations, i.e., using the existing regulations that provide for the use of alternative compliance measures.<sup>6</sup> The information required to be submitted in a DWOP focuses on characterizing the production system on a component basis, including the following: structural aspects of the facility (fixed, floating, subsea); stationkeeping (includes mooring system); wellbore, completion, riser systems; safety systems; offtake; and hazards and operability of the production systems.

By design, the DWOP is able to look at the components of a proposed development system to see how they relate to previously approved production systems. Information is gathered for the individual components of the various types of deepwater production systems and integrated into a review that is focused from a total systems perspective. For example, the mooring system for an FPSO may be analogous to a previously approved semisubmersible-based floating production system or spar.

The FPSO system operations deviate from historical activities in the GOM by the number and variety of systems that interface with the production system. Perhaps one of the more notable differences is the close proximity of produced oil offtake by shuttle tankers and their interface with production processing. According to the United Kingdom's Health and Safety Executive, the greatest single marine risk is that of collision between the FPSO and the offtake tanker.<sup>7</sup> The total system perspective of the DWOP will allow MMS to investigate the technical and operability aspects of the close proximity activities associated with an FPSO. The marine interfaces with the production systems such as offtake to shuttle tankers (equipment, communications, deployments, safety devices, and procedures) will also be investigated by this total system approach. All this is done in a staged approach that reflects the operator's state of knowledge regarding the project and provides an early opportunity for the operator and MMS to agree on the proposed development strategy (design basis, equipment, safety systems and operating philosophy) prior to major project commitments (expenditures).

The DWOP also provides the mechanism for MMS to move forward with actions on a development project even though all the technical issues have not been completely identified or resolved. Designed flexibility by basing DWOP information on a component basis allows unique technologies (new to the GOM) to be ad-

ressed without revising the regulations and other existing guidelines. The DWOP provides MMS with the ability to determine that the operator has designed and built sufficient safeguards into the production system to prevent the occurrence of significant safety or environmental incidents. A key to the DWOP process, particularly for FPSO's, is early submittal and review of the Conceptual and Preliminary Parts. The MMS cannot stress this point enough. Operators should consider the Conceptual and Preliminary Parts of the DWOP to be critical in the path of the development project, and plan their submittals to ensure there will be no delay in obtaining the necessary approvals. Table 1 shows a general timeline based on an operator's typical project schedule.

Some of the significant issues that must be discussed in a DWOP include mooring and fluid transfer to the FPSO from the subsea production equipment, marine and production system interfaces, offloading safety procedures, verification and classification of the FPSO, and hazards analysis. Imbedded within these discussions would be issues such as manning during hurricanes, offloading intentions in advance of a hurricane, and critical operations contingencies (for example, shutdown based on environmental conditions). Further elaboration of these significant issues follows, representing an evolving understanding of FPSO operations by MMS. It is important to note that this list will likely expand once an operator formally submits a project involving FPSO operations.

**Mooring and Fluid Transfer to FPSO from Subsea.** Discussions with operators, owners, manufacturers, and classification groups to date indicate that a Gulf of Mexico FPSO would likely be designed with a turret mooring arrangement to allow the FPSO to weathervane, coupled with the use of a fluid swivel for the transfer of fluids between the turret (and subsea production systems) and the FPSO. The MMS recognizes that there are numerous turret mooring and production swivel systems installed on FPSO's throughout the world. There is no experience operating FPSO's in the GOM, and MMS's understanding of such technology is still evolving. Absent historical performance data for the GOM, MMS considers this as new technology. The Preliminary Part of the DWOP would address issues such as design, pressure ratings, leak paths, penetrations, emergency shutdown (ESD) functions, instrumentation and monitoring systems, and other safety and pollution prevention aspects associated with this equipment.

**Marine and Production System Interfaces.** Consistent with the intent of the DWOP (that is, a total systems review), MMS is interested in the interfaces between the marine and production systems. The test for gaining acceptance of these interfaces is to demonstrate that they provide a "degree of protection, safety, or performance equal to or better than that intended to be achieved by the regulations."<sup>8</sup> The design, operation, and testing of the interface components such as safety devices, communication procedures, and the like must also ensure reliability. The MMS regulations further require an operator to use the best available and safest technologies (BAST) "wherever failure of the equipment would have a significant effect on safety, health, and the environment."<sup>9</sup>

As part of any proposal, a description of how these devices are linked to facility and subsea ESD systems would be reviewed for conformance with BAST requirements. The burden of proof is on the operators to demonstrate that they are using BAST, and that any alternative technologies provide an equal or better degree of safety.

**Mooring and Riser System Design.** The riser and mooring systems may be two of the most technically challenging aspects for an FPSO in the deepwater GOM.<sup>10</sup> The MMS is particularly interested in how these interface and interact with the components of an FPSO, including each other. The MMS will require an operator to demonstrate that the design and operation of the riser and mooring systems are suitable for the environment in which the FPSO will operate.

**Standards, Guidelines, and Joint Industry Projects.** In the discussions with industry, MMS has become aware of initiatives such as "Offshore Loading Safety Guidelines" being developed by the Oil Companies International Marine Forum (OCIMF) that make specific recommendations about safety systems, contractual issues, etc., to improve the safety associated with shuttle tanker operations in close proximity to an FPSO. Several joint industry projects address the risks and challenges of shuttle tankers offloading oil from FPSO's. There are also recommendations in a report titled "Close Proximity Study" prepared by the United Kingdom Health and Safety Executive. The MMS continues to review these and similar documents to determine what concerns industry and the other regulatory groups have regarding FPSO operations, and how the concerns are mitigated.

**Verification and Classification.** Concerns about design and verification of FPSO's have been discussed throughout the industry, by the International Regulators Forum, and in the media. The E&P Forum FPSO/FSU Workshop, held June 2-4, 1998, provided a forum for the discussion of this subject in detail. Classification groups, regulatory groups, operators, and shipyard representatives clarified concerns. Attendees at the E&P Forum provided several recommendations for addressing the concerns about the construction and verification of FPSO's. It is unclear to MMS if the concerns raised to date pertaining to verification and classification were directed at specific projects (and shipyards), or if they are intended for the entire classification process. The MMS remains concerned and must be assured that the verification process for an FPSO project is credible.

**Conservation review.** The MMS reissued the conservation information Notice to Lessees (NTL) in July 1998.<sup>11</sup> The NTL describes how MMS will obtain conservation information about Gulf of Mexico OCS Region deepwater or subsea development projects. The purpose of the conservation review is to ensure development of economically producible reservoirs in accordance with sound conservation, engineering, and economic practices. Gas disposition remains one of the main conservation issues for an FPSO in the Gulf of Mexico OCS.

## Risk Analysis

The MMS has begun to evaluate the role of risk analysis in the decision process for FPSO operations in the GOM. Historically, MMS has relied very little on formal risk analysis for technical decisions. Because of the uniqueness of the FPSO compared with other floating production systems operating in the GOM, and the experience gained with operating these systems worldwide under a range of conditions and regulatory regimes, MMS believes there is an opportunity to use risk studies to help with decisions. The MMS encourages an operator to evaluate the risks associated with FPSO operations in the GOM and, where feasible, compare such to existing operating systems. Comparisons should be keyed to similar operating environments. Operating experience gained by the industry serves as a basis for evaluating measures designed to reduce risk levels. The MMS actively participated in a recently completed study titled "Total Risk Assessment and Reliability of a Floating Production, Storage, and Offloading (FPSO) System in the Gulf of Mexico"; the results of this study are presented in other papers at the 1999 OTC. Understanding the risk assessment process, mainly from a qualitative standpoint, and the potential risk reducing measures have been particular interests that MMS has tried to track throughout the risk study.

Recently, MMS has engaged the industry in discussions of the feasibility of developing a comparative risk analysis methodology. The intent is to establish a means to compare FPSO's to the systems that are already deployed and operating in the GOM (spars, TLP's, subsea systems, fixed platforms, compliant towers). While such a risk comparison "tool" is not intended to be the sole basis for approvals, MMS believes it could help both industry and the regulatory agency with decisions about FPSO's (and other development systems that are untested in the GOM).

## MMS/USCG Dialogue

The MMS and U.S. Coast Guard engaged in an active dialogue about FPSO issues during the final stages of the preparation of a memorandum of understanding (MOU) designed to delineate each agency's responsibilities for oil and gas activities on the OCS. Both agencies signed the MOU in December 1998; appended to it is a delineation of jurisdictions regarding floating production system components, operations, and issues. The component breakout (for example, turrets, mooring, hull) accompanying the MOU generically delineates responsibilities for FPSO's.

A letter from MMS to the USCG in September 1998 requested clarification of several FPSO parameters under Coast Guard regulatory jurisdiction. Such clarification was noted as necessary for the development of the FPSO environmental impact statement, and has implications to the design and operation of any FPSO in the GOM. The USCG responded to MMS questions in a letter dated November 16, 1998. The issues delineated in the USCG's response to MMS focused on the designation of an FPSO as a vessel; crude oil storage; crude oil offloading versus lightering; single- versus double-hull requirements for the FPSO; the ability to establish safety zones around the FPSO; requirements for attendant vessels during offloading; and the relevance of risk assessment studies to future USCG rulemaking concerning FPSO's

and their operations. This letter, along with the MOU, will serve as the basis for further dialogue between the MMS and USCG.

## Conclusions

The MMS's mandate is to manage the development of OCS oil and gas resources while also ensuring safe operations and protecting the human and natural environment. The MMS has successfully kept pace with technological developments by investigating the issues associated with activities and enhancing the technical expertise of its staff. In a significant part of this effort, MMS has engaged industry in dialogue to obtain information that demonstrates that new technologies planned for use offer at least an equivalent level of safety and protection. The MMS recognizes the FPSO as new technology for the Gulf of Mexico OCS.

Experiences to date in the development of deepwater GOM projects, and with FPSO operations around the world, show that we can expect surprises. Examples include environmental conditions that may not be anticipated, project delays for one reason or the other, new technologies and techniques, reliance on sensors to control remote systems, and operational uncertainties associated with extending the proven technologies beyond their demonstrated capabilities. The MMS has taken a cautious approach toward decisions in deepwater, an approach likely to continue as the industry looks to the FPSO as a development option.

The potential for an FPSO-based development in the Gulf of Mexico OCS remains an unknown — there has not been a detailed plan submitted to the MMS as yet. The dialogue with industry continues, however, to support the environmental and technical decisions that will be necessary before an FPSO can operate in the Gulf of Mexico OCS. Once a formal project has been identified, the Deepwater Operations Plan process will be a key factor in the total system review of the development. The MMS encourages operators to use the DWOP process as a means to begin an early dialogue about the design and operation of an FPSO.

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**TABLE 1 — GENERALIZED TIMING FOR THE SUBMITTAL OF A DWOP**

Commercial Discovery

Conceptual Selection of Development Scenario

- **Submit Conceptual Part of DWOP**

Preliminary Engineering

Project Design and Identification of Alternative Compliance Measures Project

- **Submit Preliminary Part of the DWOP**

Procurement of Long Lead-time Items

Detailed and Final Project Design

Project Approval by Operator

Fabrication and Integration

- factory acceptance testing; site integration testing; procurement activities

Installation and Commissioning

Startup and Operations

- **Submit Final Part of the DWOP 90 Days After Production Has Begun**