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中华人民共和国石油天然气行业标准

SY/T 6110—2008

中文/English

代替 SY/T 6110—2002, SY/T 6313.2—1998, SY/T 6365—1998

气藏描述方法

The method for gas reservoir description

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前 言

本标准整合修订并代替 SY/T 6110—2002《碳酸盐岩气藏开发地质特征描述》、SY/T 6313.2—1998《油气水界面确定方法 气水界面》和 SY/T 6365—1998《油气藏原始地层压力及压力系统确定方法》。

本次修订与 SY/T 6110—2002, SY/T 6313.2—1998 和 SY/T 6365—1998 相比, 主要变化如下:

- 应用范围进行了扩展, 除适用于碳酸盐岩天然气气藏外, 还适用于碎屑岩天然气气藏和凝析气藏;
- 以 SY/T 6110—2002 主要内容、大纲作为主框架, 按不同类型气藏和不同开发阶段气藏描述的要求进行了扩充和修订, 并纳入 SY/T 6313.2—1998、SY/T 6365—1998 的主要内容;
- 气藏描述的编制原则突出了根据不同的开发阶段, 充分利用动、静态相结合方法, 建立气藏精细地质模型, 描述气藏原始地质储量和气藏剩余储量分布的思想;
- 储量计算部分补充了动态储量计算内容;
- 补充了气藏渗流特征及产能评价、气藏预测地质模型和气藏开发潜力分析等内容。

本标准由油气田开发专业标准化技术委员会提出并归口。

本标准起草单位: 中国石油西南油气田分公司勘探开发研究院。

本标准主要起草人: 陈京元、朱晓惠。

本标准所替代标准的历次版本发布情况为:

- SY/T 6110—1994, SY/T 6110—2002;
- SY/T 6313.2—1998;
- SY/T 6365—1998。

本标准以中文和英文两种文字出版。当英文和中文两种版本有歧义时, 以中文版本为准。

本标准英文翻译单位: 西南石油大学、中国石油西南油气田分公司勘探开发研究院。

本标准主要翻译人: 杜志敏、付晓文。

气藏描述方法

1 范围

本标准规定了气藏描述的内容与要求。
本标准适用于碳酸盐岩和碎屑岩的气藏、凝析气藏，其他类型气藏可参照执行。

2 规范性引用文件

下列文件中的条款通过本标准的引用而成为本标准的条款。凡是注日期的引用文件，其随后所有的修改单（不包括勘误的内容）或修订版均不适用于本标准。然而，鼓励根据本标准达成协议的各方研究是否可使用这些文件的最新版本。凡是不注日期的引用文件，其最新版本适用于本标准。

- SY/T 5154 油气藏流体取样方法
- SY/T 5368 岩石薄片鉴定
- SY/T 5440 天然气井试井技术规范
- SY/T 5543 凝析气藏流体物性分析方法
- SY/T 5579.2 油藏描述方法 第2部分：碎屑岩油藏
- SY/T 5615 石油天然气地质编图规范及图式
- SY/T 6098 天然气可采储量计算方法
- SY/T 6101 凝析气藏相态特征确定技术要求
- SY/T 6168 气藏分类
- DZ/T 0217 石油天然气储量计算规范

3 气藏描述的目的、任务和要求

3.1 目的

气藏描述的目的在于以天然气地质学理论为指导，以最新的开发技术为手段，通过地质、地震、测井与气藏工程多学科紧密结合，在三维空间综合量化描述气藏的各种特征，为气藏开发决策提供地质依据。

3.2 任务

气藏描述的任务是利用地质、地震、测井、测试及生产资料，通过静、动态结合分析，对气藏地层、构造、沉积相、储层、渗流、产能及生产动态等特征进行定量描述，建立气藏地质模型，计算气藏储量，研究气藏剩余储量分布，从而为合理开发气藏制定开发战略和技术措施提供必要的、可靠的地质依据。气藏描述贯穿于气藏开发的始终。

3.3 要求

气藏描述划分为开发早期、开发中期、开发晚期三个阶段。气藏开发各阶段对气藏描述的任务和要求不同，不同开发阶段的描述见表1。

4 气藏描述的内容

4.1 气藏概况

4.1.1 地理与交通

所处地理位置、交通状况、环境状况。

表 1 不同开发阶段气藏描述的要求

气藏描述阶段	所拥有的主要资料	储层	沉积相	构造研究精度	地质模型 网格精度
早期	1. 开发初期的静态资料; 2. 钻井、取心、测井资料; 3. 地震资料及精细处理结果; 4. 气井测试及试采资料	碳酸盐岩: 段或亚段; 碎屑岩: 砂 层组或小层	亚相或 微相	碳酸盐岩: 各储层 1 : 50000 构造图, 构造幅度不大于 100m (中- 高陡构造), 不大于 50m (低 缓构造), 不大于 20m (三维地震 的低缓构造); 断层: 断距不小于 20m, 长度不小于 500m。 碎屑岩: 提供顶面或标准层不 小于 1 : 100000 构造图, 描述三级 以上断层	根据不 同的开 发阶段 和目的 选择相 应的网 格精度
中期	1. 分层测试、试井生产动态资料; 2. 开发测井资料	碳酸盐岩: 段或亚段; 碎屑岩: 小 层	微相	碳酸盐岩: 各储层 1 : 50000 构造图, 构造幅度不大于 100m (中- 高陡构造), 不大于 50m (低 缓构造), 不大于 20m (三维地震 的低缓构造); 断层: 断距不小于 20m, 长度不大于 500m。 碎屑岩: 提供各油层不小于 1 : 100000构造图, 构造幅度不小 于 10m, 构造面积不小于 0.3km ² ; 断层: 断距大于 5m, 长度不小于 300m	
晚期	井网及动静态资料、加密 井资料等	碳酸盐岩: 段或亚段; 碎屑岩: 流 动单元	微相	碳酸盐岩: 各储层 1 : 50000 构造图, 构造幅度不大于 100m (中- 高陡构造), 不大于 50m (低 缓构造), 不大于 20m (三维地震 的低缓构造); 断层: 断距不小于 20m, 长度不大于 500m。 碎屑岩: 提供单层顶底面不小 于 1 : 100000 构造图, 构造幅度不 大于 5m, 构造面积小于 0.1km ² ; 断层: 断距不大于 5m, 长度小于 100m	
注: 复杂类型油气田可参考此表。					

4.1.2 区域地质

所处沉积盆地、大地构造单元及位置。

4.1.3 勘探简况

勘探历程包括气藏范围内完成的地震、钻井、测井、取心及分析化验工作量, 各井完井测试情况, 储量申报简况。

4.1.4 开发简况

开采历程包括开采时间、单井产量、压力变化、生产井数、累计产量、采气速度及采出程度等动态情况。

4.2 地层特征描述

4.2.1 区域地层

4.2.1.1 气藏内全部沉积岩系都进行地层层序和岩性描述，并绘制地层综合柱状图。

4.2.1.2 钻遇的地层以阶（组）、段或亚段为单位描述，未钻达的深部地层以统或阶（组）为单位描述。

4.2.2 储盖组合

储层和盖层的层位、岩性、厚度及其变化与分布，并作储盖组合的评价。

4.2.3 目的层特征

4.2.3.1 描述内容包括层位、深度、岩性、厚度、接触关系，并按此内容编制目的地层对比图。

4.2.3.2 描述目的层地震响应特征和测井电性特征。

4.2.4 小层的细分与对比

4.2.4.1 主要采用岩性与电性对比，用标准层控制的方法进行追踪。

4.2.4.2 小层命名：系和统用年代地层单位，组、段、亚段用岩石地层单位，层用地下地层单位。

4.2.4.3 编制小层对比图，描述各小层的综合体纵横向变化。

4.3 构造特征描述

4.3.1 区域构造

描述局部构造所在盆地的名称、性质、二级构造单元名称及其简要特征，并编制气田的构造位置图。

4.3.2 构造特征

利用地质、测井和地震资料精细描述含气构造的类型和名称、高点的位置和地面海拔、高点出露地层、构造圈闭的形态、闭合面积、闭合度、长短轴的长度及方向、背斜两翼倾角，并编绘构造剖面图和构造图。

4.3.3 断层特征

利用地质、测井和地震资料描述断层的类型、组系、平面分布、数量及其组合关系，主要断层的产状、性质、落差、延伸长度、与高点和轴线关系，两盘对接地层的层位和岩性、断层起始和消失部位的地层、断层开启与封闭性。提交主断层剖面图。

4.3.4 断块区和断块特征

描述各断块区或断块的构造特征、切割关系、面积、岩层产状等。断块面积计算应以反映主要目的层构造形态的顶或底界构造图为准。

4.4 沉积相描述

4.4.1 区域沉积背景

区域地层层序、区域构造史、沉积史、所描述储层的沉积体系类型、物源区及母岩类型、古气候、古水流等的描述。

4.4.2 储层单井岩心岩相

以取心井岩心、岩屑资料为基础，结合区域沉积相背景，描述岩石颜色、成分、沉积结构及沉积构造，建立沉积相标志（岩石学标志、矿物学标志、古生物标志和地球化学标志等）。对典型井在纵向上进行沉积相、亚相及微相划分，并进行单井垂向层序及沉积旋回分析。

4.4.3 储层测井相分析

4.4.3.1 利用测井资料研究沉积微相。以取心段为基础，建立地质—测井相解释模型，对测井资料进行电相分类，建立测井沉积相、亚相及微相模式。

4.4.3.2 利用测井资料进行多井沉积相、亚相及微相层段的划分。

4.4.4 储层地震相的描述

进行高分辨率处理，利用测井划分沉积相并对地震沉积相进行刻度，建立地震沉积相模式。

4.4.5 沉积相及微相平面展布

以多井测井沉积相及微相划分为骨架，利用宏观地震模式，以地震为井间预测手段，进行沉积相和沉积微相纵横向变化预测，编制沉积相平面分布图。

4.5 裂缝特征描述

4.5.1 储层裂缝描述

4.5.1.1 露头裂缝描述：

选择与气藏的层位相同、储层及构造的类型相同（或相近似）的露头区作裂缝类比调查，测量各裂缝组系的产状、方位、密度、间距；描述裂缝的几何形态、大小、穿层和相互切割关系；描述裂缝的开启程度及充填程度；描述洞穴的大小、密度与分布、充填状况；采集有代表性的岩样，并作裂缝素描和照相；阐述裂缝特别是构造裂缝与构造位置的关系，建立裂缝地质模式。

4.5.1.2 岩心裂缝描述：

碳酸盐岩岩心裂缝描述内容包括裂缝产状、形态、充填程度、充填物类型、分级和分类、组系、密度、期次及发育的影响因素；碎屑岩岩心裂缝描述内容包括裂缝成因划分、产状、开启程度、地应力场与裂缝关系、分布规律、开启与闭合规律等。

4.5.1.3 微观裂缝描述：

利用岩石薄片（包括铸体薄片、全直径岩心大薄片）描述裂缝的微观特征，岩石薄片中的裂缝鉴定按 SY/T 5368 的规定执行。

4.5.2 储层裂缝识别

4.5.2.1 地球物理方法识别裂缝：

利用测井资料定性划分裂缝发育层段；利用成像测井、倾角测井等资料描述裂缝（包括类型、条数、密度、张开度、大小等），识别裂缝的产状和延伸方向，划分裂缝发育层段。

4.5.2.2 动态资料判断裂缝：

应用气井产能和压力变化、试井成果以及井间干扰等资料，判断裂缝的组系及其延伸的方向，估算裂缝系统的发育程度。

4.5.3 裂缝的定量评价

4.5.3.1 对岩心裂缝进行定量描述。

4.5.3.2 利用关键井资料建立裂缝定量测井解释评价模型，计算岩石力学参数（如泊松比、杨氏模量等）、裂缝参数（包括裂缝孔隙度、裂缝渗透率、裂缝张开度、含水饱和度、裂缝指数等）。

4.5.3.3 综合利用多种测井信息计算的裂缝参数为特征变量来系统评价裂缝。有条件时，建立裂缝各参数的空间展布模型。

4.5.4 裂缝发育控制因素

储层岩性、岩石构造、岩石力学性质、断层等因素。

4.5.5 综合预测裂缝

综合岩石力学性质、钻井、测井、地震、局部构造特征及动态资料等因素分析裂缝发育规律，预测裂缝发育区带。

4.6 储层特征描述

4.6.1 关键井储层综合评价

应用关键井的静、动态资料，对储层的四性关系进行综合分析，建立解释图版，编制储层综合柱状图，作为其他井解释及井间对比的标准。

4.6.2 储层岩石学特征

描述储层岩石的组分、填隙物、结构、显微构造、胶结物等特征。

4.6.3 储集空间特征

储集空间按大小、形态一般分为孔、洞、缝三大类，划分标准按 SY/T 5368 规定执行。

4.6.4 孔隙结构特征描述

4.6.4.1 利用岩石薄片、铸体薄片、扫描电镜、图像分析等资料定性描述孔喉的形态、大小及组合。

4.6.4.2 利用压汞法确定孔隙结构参数，定量描述孔喉微观结构。

4.6.5 储层参数

4.6.5.1 主要包括孔隙度、渗透率、含气饱和度、相对渗透率、岩石压缩率、孔隙结构参数、裂缝参数、基质孔隙层有效厚度和裂缝层段有效厚度。

4.6.5.2 储层参数根据岩心分析、测井和试井解释方法求取。

4.6.6 储层非均质性

描述储层参数及储渗体在纵横向上的变化，评价储层的非均质程度。

4.6.7 隔层

描述隔层的岩石类型、划分隔层厚度标准及隔层的分布状况。

4.6.8 储层分类

4.6.8.1 储层分类指标主要包括孔隙度、渗透率、有效厚度、孔喉结构参数、储量大小、砂体面积、砂体钻遇率、泥质含量、胶结物含量、层内非均质参数等。应根据区域性地质勘探及开发情况，选择确定适合本气田（藏）的分类指标，并对储层分类结果进行评价。

4.6.8.2 碳酸盐岩储层通常根据岩块基质的渗透率、孔隙度和孔隙结构参数进行分类。储集层级别划分见表 2。

4.6.8.3 碎屑岩储层分类按 SY/T 5579.2 的规定执行。

4.6.9 储渗类型

以渗透率、储集空间类型与试井等资料相结合，按钻井显示、储层渗透率与基质渗透率比、压力恢复特征、初期产能特征、主要储集空间、主要渗滤通道等因素确定储渗类型，划分为孔隙型（或孔洞型）、裂缝型（或缝洞型）、裂缝—孔隙型、孔隙—裂缝型四类。

表 2 碳酸盐岩储集层级别划分表

储集层级别	渗透率 $10^{-3} \mu\text{m}^2$	孔隙度 %	中值喉道宽度 μm	排驱压力 MPa	分选系数
I	≥ 10	≥ 12	≥ 2	< 0.1	≥ 2.5
II	$< 10 \sim 0.1$	$< 12 \sim 6$	$< 2 \sim 0.5$	$< 1 \sim 0.1$	$< 2.5 \sim 2$
III	$< 0.1 \sim 0.001$	$< 6 \sim 2$	$< 0.5 \sim 0.05$	$< 5 \sim 1$	$< 2 \sim 1$
IV	< 0.001	< 2	< 0.05	≥ 5	< 1

注：储层的孔隙度下限可视具体的气藏而定。

4.6.10 储层预测

4.6.10.1 应用地震、测井、地质资料预测储层（包括厚度、物性、储量丰度等），进行储层特征井间横向预测，研究井间储层参数的变化规律。

4.6.10.2 预测各类储层成因单元几何形态、规模以及成因单元间的连通性。

4.6.10.3 结合单井储层参数，编绘储层参数变化图件。

4.6.10.4 采用地震预测技术对储层进行含气性预测。

4.6.11 储层评价

4.6.11.1 储层有效性评价：确定储层有效物性下限。

4.6.11.2 敏感性评价：确定储层易伤害性。

4.6.11.3 整体评价：综合单井评价、地震预测及地质认识成果资料，利用各项储产层参数对全气

藏进行储层分类评价,明确各类储产层在剖面上和平面上的分布及变化规律。

4.7 流体、压力和温度特征描述

4.7.1 流体性质

4.7.1.1 天然气化学组分特征,包括组分、重烃含量、凝析油含量、稀有气体含量等。

4.7.1.2 高压物性特征,包括压缩系数、体积系数、密度、黏度、偏差系数等。

4.7.1.3 凝析气藏需确定开发过程中的相态、各相组成和参数(密度、黏度、体积系数和偏差系数)随地层压力衰竭的变化;凝析气藏的流体取样、配样及分析按 SY/T 5154 和 SY/T 5543 的规定执行。

4.7.1.4 地层水性质,包括水型、离子含量、总矿化度、密度、pH 值、微量元素等。

4.7.2 压力、温度系统

4.7.2.1 描述气藏各井区的原始地层压力、压力梯度。单井原始地层压力资料可通过实测或试井方法确定,参见 SY/T 5440。

4.7.2.2 根据静态地质特征、流体性质、地层压力、试采及井间干扰等资料,综合判断气藏压力系统。

4.7.2.3 气藏原始地层压力是利用各单井气层中部深度原始地层压力与深度回归直线,在选定的基准深度上求得的值。

4.7.2.4 根据气藏原始地层压力与相同埋深的静水柱压力比值求取压力系数,并按 SY/T 6168 的规定判断气藏属于高压、中压或低压气藏。

4.7.2.5 描述气藏静地温与地温梯度、气井流温与流温梯度。地层温度通过实测确定。

4.7.3 流体分布

4.7.3.1 描述地层水在气藏内分布的状况,确定气水界面。

4.7.3.2 对于具有同一水动力学系统的各种圈闭类型的气藏,其气水界面的确定主要是利用气水压力梯度差异确定的气水井压力交汇法,可按式(1)计算气水界面:

$$D_{Gwc} = \frac{(G_{Dw} D_w - G_{Dg} D_g) - (p_{wi} - p_{gi})}{G_{Dw} - G_{Dg}} \dots\dots\dots (1)$$

式中:

D_{Gwc} ——气水界面垂直井深的数值,单位为米(m);

D_g ——产气井段中部垂直井深的数值,单位为米(m);

D_w ——产水井段中部垂直井深的数值,单位为米(m);

G_{Dg} ——气层压力梯度的数值,单位为兆帕/米(MPa/m);

G_{Dw} ——水层压力梯度的数值,单位为兆帕/米(MPa/m);

p_{wi} ——产水井段中部原始地层压力的数值,单位为兆帕(MPa);

p_{gi} ——产气井段中部原始地层压力的数值,单位为兆帕(MPa)。

4.7.3.3 此外可根据资料情况采用直接测定含水饱和度的方法、利用毛管压力确定的方法、利用气水物性差异划分的方法、不稳定试井方法等来确定气水界面。

4.7.3.4 编制气水界面分布图。

4.7.3.5 分析控制气、油、水分布的地质因素。

4.7.3.6 判别凝析气藏是否带油环,按 SY/T 6101 的规定执行。

4.8 气井渗透特征及产能评价

4.8.1 渗流特征分析

通过测试资料对气井的渗流特征进行分析。

4.8.2 气井产能评价

分析气井产能及影响因素,评价增产措施后井底污染状况改善程度。

4.9 气藏类型与驱动类型

4.9.1 气藏类型

4.9.1.1 按气藏圈闭类型、几何形态、储渗类型、流体性质、油气水关系、弹性能量、压力系数等因素确定。

4.9.1.2 凝析气藏则根据流体相态确定油、气藏类型。同时应在相态研究基础上确定储层凝析气贫富类别。相关方法按 SY/T 6101 规定执行。

4.9.2 气藏驱动类型

按驱动能量确定气藏驱动类型。判断水体的范围、规模和能量、边底水锥进情况，预测水体在气藏开采过程中的活跃程度。

4.10 气藏静态地质模型

4.10.1 构造模型

描述气藏构造几何形态及断层分布。

4.10.2 储层模型

描述气藏范围内储层建造结构及其各种属性的空间分布。

4.10.3 流体模型

描述气藏中气、油、水的分布状态，流体物理化学性质的分布情况。

4.11 储量计算及评价

4.11.1 容积法储量

按 DZ/T 0217 执行。

4.11.2 动态法储量

利用物质平衡法等计算井区和气藏的动态储量。

4.11.3 可采储量

按 SY/T 6098 计算气藏可采储量。

4.11.4 储量评价

4.11.4.1 资料与计算参数可靠性评价。

4.11.4.2 对各种方法计算的储量进行对比评价。

4.11.4.3 对储量丰度在平面上的变化进行评价。

4.11.4.4 评价剩余储量和剩余可采储量。

4.12 气藏预测地质模型

4.12.1 地质储量拟合

在静态地质模型网格粗化后形成的数值模拟地质模型的基础上，拟合地质储量。

4.12.2 生产历史拟合

拟合的开发指标主要包括：产量及累积产量、气水比、压力。

4.12.3 剩余储量分布

在气藏数值模拟生产历史拟合后，形成储层剩余储量空间量化分布场。

4.12.4 气藏预测地质模型

静态地质模型经过气藏数值模拟生产历史拟合后，即形成了气藏预测地质模型。

4.13 气藏开发潜力

对气藏目前压力和剩余储量的分布情况进行分析，描述气藏开发潜力。

5 气藏描述报告

5.1 报告内容

报告内容可根据不同勘探开发阶段的描述对象调整相关章节。包括：气藏概况；地层特征描述；

构造特征描述；沉积相描述；裂缝特征描述；储层特征描述；流体、压力和温度特征描述；气井渗流特征分析和产能评价；气藏类型与驱动类型；气藏静态地质模型；储量计算；气藏预测地质模型；气藏开发潜力。

5.2 附件

附件包括地震精细处理解释研究报告、测井精细处理解释研究报告。

5.3 附表册

气藏描述附表可包括：地层分层数据表；取心及岩心分析统计表；油气水显示表；钻井基础数据表；试油成果汇总表；构造要素与断层要素表；储层与有效厚度数据表；单井储层对比表；岩心孔洞统计表；岩心裂缝统计表；孔隙结构特征数据表；孔、渗、饱测试数据表；储层分类标准与分类结果汇总表；天然气组分汇总表；地层水组分汇总表；凝析油组分汇总表；天然气物性数据表；容积法储量计算数据表；气井试井数据表；气井生产动态数据表；压降储量计算数据表；气藏历次储量计算结果对比表。

5.4 附图册

气藏描述附图可包括：气田地理交通位置图；区域地质构造图；地震测线与气藏构造图；勘探成果图；测井解释成果图；气藏的纵横剖面图；储层对比图；孔隙结构特征图；沉积、储层综合柱状图；沉积相平面分布图；孔隙度、渗透率、含气饱和度平面等值线图；有效储层厚度平面分布图；油、气、水分布平面图与剖面图；压力与海拔深度关系曲线图；温度与海拔深度关系曲线图；试井曲线分析图；压降储量图；不同阶段流体相图；气藏数值模拟网格图；气井生产史拟合图；气藏储量丰度等值线图；气藏剩余储量分布图。

图件格式按 SY/T 5615 的规定编绘。

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Standard of Petroleum and Natural Gas Industry

SY/T 6110—2008

Replace SY/T 6110—2002, SY/T 6313. 2 1998, SY/T 6365—1998

The method for gas reservoir description

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Foreword

This standard is based on SY/T 6110—2002 *The description of exploitation geologic characteristics for carbonate gas reservoirs carbonate gas reservoirs*, with the integration and modification of SY/T 6313.2—1998 *the method of determination of the oil – gas – water contact – The gas – water contact* and SY/T 6365—1998 *Methodology for the initial pressure and the hydrodynamic system in hydrocarbon reservoirs*.

Major changes in the present standard as compared with SY/T 6110—2002, SY/T 6313.2—1998 and SY/T 6365—1998 are as follows:

- The scope has been expanded to enable the standard applicable to both carbonate gas reservoirs and clastic gas reservoirs and condensate gas reservoirs.
- The main contents and outline of SY/T 6110—2002 have been used as a basic framework, and expansion and modification have been made to accommodate the requirement of reservoir description for different types of gas reservoirs and for different stages of exploitation, with the main contents of SY/T 6313.2—1998 and SY/T 6365—1998 incorporated.
- The standard has been formulated in line with such a principle that emphasizes the idea that, corresponding to different development stages, gas reservoir description should be conducted making full use of integrated dynamic and static techniques to establish detailed geologic model of the gas reservoir, and to de-

scribe the initial gas in place and the distribution of remaining reserve of the gas reservoir.

- Performance reserve estimation has been added to the reserve estimation part.
- Such contents as fluid flow characteristic, deliverability appraisal, predictive geologic model and exploitation potential analysis of the gas reservoirs have been added in.

This standard is proposed by and is under the jurisdiction of The Oil and Gas Field Exploitation Standardization Committee.

This standard is prepared by the Research Institute of Exploration and Development, Southwest Oil and Gas Field Branch, CNPC.

Major contributors to the preparation of this standard are Chen Jing – yuan and Zhu Xiao – hui.

Standards with various editions that are to be substituted for by this standard include:

- SY/T 6110—94, SY/T 6110—2002;
- SY/T 6313.2—1998;
- SY/T 6365—1998.

This standard is published in both Chinese and English. In the case of any discrepancy between the texts, the Chinese version shall prevail.

The English version of the standard is prepared by Southwest Petroleum University and the Research Institute of Exploration and Development of Southwest Oil and Gas Field Branch, CNPC, and is translated primarily by Du Zhi – min and Fu Xiao – wen.

The method for gas reservoir description

1 Scope

This standard regulates the contents and requirement of a gas reservoir description job.

The standard is applicable to carbonate and clastic gas reservoirs and condensate gas reservoirs, and the description of other type of gas reservoirs can refer to this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this standard, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications (exclude errata) do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

SY/T 5154 *Recommended practice for reservoir fluids sampling*

SY/T 5368 *Examination of petrographic thin sections*

SY/T 5440 *Technical specification for gas well testing*

SY/T 5543 *Recommended practice for analysis of fluid properties of condensate gas reservoirs*

SY/T 5579.2 *Method of reservoir description: Part 2 Clastic petroleum reservoirs*

SY/T 5615 *Specification and format for oil and gas geologic mapping*

SY/T 6098 *Recommended practice for recoverable gas reserve calculation*

SY/T 6101 *Technical specification for determination of phase behavior of gas condensate res-*

ervoirs

SY/T 6168 *Classification of gas reservoirs*

DZ/T 0217 *Specification for oil and gas reserve calculation*

3 Objectives, task and requirement of gas reservoir description

3.1 Objectives of gas reservoir description

Guided by natural gas geology theories, using latest development techniques as tools, and based on a tight integration of geologic, seismic, well logging and gas reservoir engineering disciplines, gas reservoir description is aimed at comprehensive and quantitative characterization of variables of gas reservoirs in 3D so as to provide geologic warrant for the decision making of gas reservoir development.

3.2 Task of gas reservoir description

The task of gas reservoir description is to use geologic, seismic, well logging, testing and production data, through integrated static and performance analysis, to quantitatively characterize the stratigraphic formation, structure, sedimentary facies, reservoir rock, fluid flow, deliverability and production performance of the gas reservoir, and to establish the geologic model, calculate the reserve and study the distribution of remaining reserve of the gas reservoir, so as to provide essential and reliable geologic warrant for planning strategy and technical measures for the rational development of a gas reservoir. Gas reservoir description is a process that goes throughout the entire development period of a gas reservoir.

3.3 Requirement of gas reservoir description

Gas reservoir description can be divided into three stages: early, middle and late development phase description. The task and requirement of

gas reservoir description differ in accordance with specific stages of development, as described in Table 1.

Table 1 Requirement of gas reservoir description for different development stages

Stage	Early development phase	Middle development phase	Late development phase
Major data available	1. static data from initial development phase; 2. drilling, core and well log data; 3. seismic data and detailed processing results; 4. gas well testing and test production data	1. zonal testing and well - test production performance data; 2. production logging data	well - pattern data, static and performance data, in - filling well data
Reservoir rock	Carbonate; Member or sub - member; Clastic; Sand unit or bed	Carbonate; Member or sub - member; Clastic; bed	Carbonate; Member or sub - member; Clastic; flow unit
Sedimentary facies	Sub - facies or microfacies	microfacies	microfacies
Accuracy of structure study	Carbonate rock; 1 : 50000 structure map of individual reservoir beds, structure amplitude $\leq 100\text{m}$ (moderately to highly steep structure), $\leq 50\text{m}$ (gentle structure), $\leq 20\text{m}$ (gentle structure depicted on 3D seismic profile); fault; throw $\geq 20\text{m}$, length $\geq 500\text{m}$. Clastic rock; Provide bed top or datum bed structure map with a scale of 1 : 100000 or larger, and describe faults of class - III or larger	Carbonate rock; 1 : 50000 structure map of individual reservoir beds, structure amplitude $\leq 100\text{m}$ (moderately to highly steep structure), $\leq 50\text{m}$ (gentle structure), $\leq 20\text{m}$ (gentle structure depicted on 3D seismic profile); fault; throw $\geq 20\text{m}$, length $\leq 500\text{m}$. Clastic rock; Provide structure map of each pay zone with a scale of 1 : 100000 or larger. Structure amplitude $\geq 10\text{m}$, structure area $\geq 0.3\text{km}^2$. Fault; throw $> 5\text{m}$, length $\geq 300\text{m}$	Carbonate rock; 1 : 50000 structure map of individual reservoir beds, structure amplitude $\leq 100\text{m}$ (moderately to highly steep structure), $\leq 50\text{m}$ (gentle structure), $\leq 20\text{m}$ (gentle structure depicted on 3D seismic profile); fault; throw $\geq 20\text{m}$, length $\leq 500\text{m}$. Clastic rock; Provide bed top and bottom structure map with a scale of 1 : 100000 or larger. Structure amplitude $\leq 5\text{m}$, structure area $< 0.1\text{km}^2$. Fault; throw $\leq 5\text{m}$, length $< 100\text{m}$
Grid accuracy of geologic model	Select appropriate grid density in accordance with individual development stage and corresponding goal		
Note: Complex oil gas field can refer to the table.			

4 Contents of gas reservoir description

4.1 General information about the gas reservoir

4.1.1 Geography and transportation

Geographic location, transportation status and environmental status of the gas reservoir

4.1.2 Regional geology

Sedimentary basin, tectonic division and locality in which the gas reservoir is situated

4.1.3 Exploration summary

Exploration history of the gas reservoir, including amounts of seismic, drilling, well logging, core sampling and sample analysis and testing work that have been done within the extension of the gas reservoir; status of well completion testing for each of the wells, and briefing of reserve reporting.

4.1.4 Development summary

Production history of the gas reservoir, including such performance information as duration of production, single-well productivity, pressure change, number of producing wells, cumulative production, rate of yield and degree of reserve recovery.

4.2 Stratigraphic characterization

4.2.1 Regional strata

4.2.1.1 Describe the stratigraphic sequence and lithology of all sedimentary strata within the extent of the gas field. And compile the composite stratigraphic column diagram.

4.2.1.2 Strata penetrated by drilling are described in Stage (Formation), Member or Sub-member. Strata at depth and not penetrated by drilling are described in Series or Stage (Formation) .

4.2.2 Reservoir-cap bed doublet

Describe the stratigraphic position, lithology, thickness and variation and distribution of the reservoir bed (s) and cap bed (s) . And make reservoir-cap bed doublet evaluation.

4.2.3 Characteristics of the target bed

4.2.3.1 The description should include stratigraphic position, depth, lithology, thickness

and formation contact relationship. Compose target bed correlation diagram illustrating the above information.

4.2.3.2 Describe the seismic-response characters and well-log electric properties of the target bed (s) .

4.2.4 Detailed division and correlation of beds

4.2.4.1 Perform the correlation mainly based on lithology and electric properties, and trace the bed by way of datum-bed control.

4.2.4.2 Naming the bed: Use chronostratigraphic units for Series and System, use lithostratigraphic units for Formation, Member and Sub-member, and use subsurface units for Bed.

4.2.4.3 Compose bed correlation diagram, describing the vertical and horizontal variation of each bed complex.

4.3 Structure characterization

4.3.1 Regional structure

Give the name and describe the nature of the basin, and give the name and describe the main characters of the tectonic sub-division in which the local structure lies. Compose tectonic location map of the gas field.

4.3.2 Structure characters

Describe in detail, using geologic, well-log and seismic data, the type, name, location and surface elevation of the structural high, formation (s) exposed on the structural high of the gas-bearing structure, and the trap configuration, closure area and height, length and extending directions of the long and short axes and angle of inclination of the limbs of the structural trap. And compose the structural cross-section diagram and structural map.

4.3.3 Fault characters

Describe, using geologic, well-log and seismic data, the type, sets, areal distribution, number and combination relationship of faults. For the major faults, describe the orientation, nature, distance of slippage, length of extension, relationship with the structural high and axis line, stratigraphic position

and lithology of juxtaposed formations on both sides of the fault, formations within which the fault starts and disappears, and the state of the fault being open or sealed. Compose cross section diagram of the major fault (s) .

4.3.4 Characters of block-faulting area and fault blocks

Describe the structural characters, cross - cutting relationship, areal dimension and formation orientation of each block - faulting area or fault block. The calculation of fault block area should be performed on the formation top or bottom structure map depicting the structural configuration of the main target bed (s) .

4.4 Description of sedimentary facies

4.4.1 Regional deposition settings

Describe regional stratigraphic sequences, regional tectonic history and depositional history, type of depositional system, provenance and type of host rocks of the reservoir rock being considered, and the relevant paleoclimate and paleocurrent.

4.4.2 Single-well lithofacies of reservoir cores

Describe, based on cores and drill cuttings of the cored well and integrating the regional sedimentary facies background, the color, composition, sedimentary fabric and structure of the rock, establishing criteria of the sedimentary facies (petrologic, mineralogical, palaeontological and geochemical criteria) . For type well (s), divide the sedimentary facies, sub - facies and microfacies on the vertical profile, and analyze the stratigraphic sequence and depositional cycle.

4.4.3 Analysis of log facies of the reservoir rock

4.4.3.1 Use well - log data to study the sedimentary microfacies. On the basis of cored interval, establish geologic - log facies interpretive model, classify electric facies for well - log data, and establish well - log models of sedimentary facies, sub - facies and microfacies.

4.4.3.2 Use log data to divide sedimentary facies, subfacies and microfacies intervals for multiple wells.

4.4.4 Description of seismic facies of the reservoir rock

Use high - resolution processing to process seismic data, and use well log to divide sedimentary facies and to demarcate seismic sedimentary facies, establishing seismic sedimentary facies model.

4.4.5 Spatial distribution of sedimentary facies and microfacies

Use divisions of multi - well sedimentary facies and microfacies as a framework, use macro - seismic model and apply seismic technique as means of inter - well prediction, predicting the spatial and vertical variations of sedimentary facies and microfacies. Compose spatial distribution map of sedimentary facies.

4.5 Fracture characterization

4.5.1 Description of fractures in the reservoir rock

4.5.1.1 Description of fractures on the outcrop;

Perform analogous investigation of fractures in a chosen outcrop area exhibiting the same stratigraphic position and same (or similar) reservoir rock and structure type with the gas reservoir. Measure the orientation, azimuth, density and spacing of the fracture sets. Describe the geometric configuration, size, state of cross - bed cutting and mutual cross - cutting relationship of the fractures. Describe the degree of openness and infilling of the fractures. Describe the size, density, distribution and infilling of caverns. Take representative rock samples, and make line drawing and take photographs of the fractures. Elaborate the relationship between fractures (especially tectonic fractures) and structural positions. Establish geologic model of the fractures.

4.5.1.2 Description of fractures in the core;

For cores of carbonate rocks, the fracture description should include the orientation, configuration, degree of infilling, nature of the infilling material, sizing and grouping, number of sets, density, timing and chronological relationship,

and controlling factors of the fractures. For cores of clastic rocks, the fracture description should include the genetic type, orientation, status of openness, relationship with the geo-stress field, regularity of distribution, and regularity of being open and sealed of the fractures.

4.5.1.3 Description of microscopic fractures: Describe the microscopic characters of fractures using petrographic thin sections (including impregnated thin sections and large thin sections made on whole core). Determination of fractures in thin sections should conform to SY/T 5368.

4.5.2 Identification of fractures in the reservoir rock

4.5.2.1 Identify fractures with geophysical methods:

Use well-log data to qualitatively determine fractured intervals, and use Formation Micrographic Imaging (FMI) and dip-log data to describe fractures (type, number, density, degree of openness, size, etc.), to determine orientation and extending directions of fractures, and to identify fractured intervals.

4.5.2.2 Identify fractures using performance data:

Use gas-well productivity and pressure variation data, well testing result and well interference data to determine the sets and extending direction of fractures and to estimate the scale of the fracture system.

4.5.3 Quantitative evaluation of fractures

4.5.3.1 Quantitatively describe the fractures in cores.

4.5.3.2 Use data from key wells to establish quantitative well-log fracture interpretation and evaluation model and to calculate rock mechanical parameters (Poisson's ratio, Young's modulus, etc.) and fracture parameters (fracture porosity, fracture permeability, fracture openness, water saturation, fracture index, etc.).

4.5.3.3 Use integrated fracture parameters obtained from various well-log data as charac-

teristic variables to systematically appraise fractures. Establish spatial distribution model of individual fracture parameters if possible.

4.5.4 Factors controlling fracture formation

Factors such as lithology of reservoir rock, structural characters, rock mechanical properties, and fault, etc.

4.5.5 Comprehensive prediction of fractures

Use integrated rock mechanical properties, drilling, well logging, seismic, local structure characters and performance data to analyze the regularity of fracture development, and to predict zones with well-developed fractures.

4.6 Reservoir rock characterization

4.6.1 Comprehensive reservoir evaluation for key wells

Use static and performance data from key wells to analyze comprehensively the relationship between lithology, electric properties, petrophysical properties and fluid properties of the reservoir rock. Compose interpretation graphs and composite reservoir column to serve as criteria for interpretation of other wells and for inter-well correlation.

4.6.2 Petrologic characters of reservoir rock

Describe characters of composition, pore-filling material, texture, microscopic structure and cement of the reservoir rock.

4.6.3 Characters of reservoir pore spaces

Reservoir pore spaces are generally grouped into three categories - pore, cavern and fracture, based on their size and configuration. Follow the criteria provided in SY/T 5368 for classification.

4.6.4 Pore structure characterization

4.6.4.1 Use petrographic thin sections, impregnated thin sections, scanning electron microscope and image analysis data to qualitatively describe the shape, size and combination of pores and throats.

4.6.4.2 Use mercury intrusion porosimetry to determine pore structure parameters and to quantitatively describe microscopic structure of pore throats.

4.6.5.1 Primary reservoir – bed parameters include porosity, permeability, gas saturation, relative permeability, rock compressibility, pore structure parameters, fracture parameters, effective thickness of porous – matrix intervals and fractured intervals.

4.6.5.2 Obtain reservoir – bed parameters by means of core analysis, well – log and well – test interpretation.

4.6.6 Reservoir-bed heterogeneity

Describe the vertical and horizontal variations of reservoir-bed parameters and poroperm bodies, and estimate the degree of reservoir-bed heterogeneity.

4.6.7 Barrier bed

Describe the lithologic type, thickness criteria for division, and distribution of the barrier bed.

4.6.8 Grading reservoir rocks

4.6.8.1 Parameters used for reservoir grading mainly include porosity, permeability, net thickness, pore structure parameters, reserve, sand – body area, ratio of sand bodies encountered by drilling, clay content, cement content and internal heterogeneity parameters. The grading criteria should be selected on the basis of regional geologic exploration and development so as to be proper for the gas field (reservoir) under study. Make evaluation of the result of reservoir grading.

4.6.8.2 Carbonate reservoir rocks are in general graded on the basis of rock – matrix permeability, porosity and pore structure parameters. The grading criteria are given in Table 2.

Table 2 Grading of carbonate reservoir rocks

Reservoir grade	Permeability $10^{-3} \mu\text{m}^2$	Porosity %	Median throat width μm	Displacement pressure MPa	Sorting coefficient
I	≥ 10	≥ 12	≥ 2	< 0.1	≥ 2.5
II	$< 10 \sim 0.1$	$< 12 \sim 6$	$< 2 \sim 0.5$	$< 1 \sim 0.1$	$< 2.5 \sim 2$
III	$< 0.1 \sim 0.001$	$< 6 \sim 2$	$< 0.5 \sim 0.05$	$< 5 \sim 1$	$< 2 \sim 1$
IV	< 0.001	< 2	< 0.05	≥ 5	< 1

Note: The porosity cut – off value for reservoir bed can be flexible for individual gas reservoirs.

4.6.8.3 Conform to SY/T 5597.2 for grading of clastic reservoir rocks.

4.6.9 Poroperm type

Determine poroperm type using integrated permeability, pore space type and well testing data, and based on shows during drilling, ratio of reservoir permeability to matrix permeability, pressure build – up characters, initial deliverability characters and dominant pore spaces and flow passages. Four poroperm types can be realized: porous (or porous – cavernous), fractured (or fractured – cavernous), fractured – porous and porous – fractured.

4.6.10 Reservoir interval prediction

4.6.10.1 Use seismic, well – log and geologic data to predict reservoir intervals (including thickness, petrophysical properties, reserve abundance, etc.), to predict horizontal variation of reservoir characters in between wells, and to study the regularity of reservoir parameter variations in between wells.

4.6.10.2 Predict the shape, size and mutual connectivity of individual genetic units of the reservoir rock.

4.6.10.3 Compose diagrams illustrating reservoir parameter variations with the incorporation

of single - well reservoir parameters.

4.6.10.4 Use seismic prediction technique to predict gas - bearing reservoir intervals.

4.6.11 Reservoir Evaluation

4.6.11.1 Evaluate the effectiveness of the reservoir bed to determine the cut - off values of petrophysical parameters.

4.6.11.2 Evaluate the damage sensibility to determine the vulnerability of reservoir damage.

4.6.11.3 Bulk evaluation: on the basis of integrated single - well evaluation, seismic prediction and geologic investigation results, use reservoir - interval and pay - zone parameters to perform reservoir grading and evaluation for the whole gas reservoir, finding out the regularity of stratigraphic and areal distribution and variation of individual types of reservoir - bed and pay - zone.

4.7 Fluids, pressure and temperature characterization

4.7.1 Fluid properties

4.7.1.1 Characteristics of chemical composition of natural gas, including components, heavy hydrocarbon concentration, condensate content and noble gas content

4.7.1.2 PVT properties, including compressibility coefficient, volume factor, density, viscosity and Z - factor

4.7.1.3 For gas condensate reservoirs, determination should be made on the variations of phase behavior, composition of individual phases and parameters (density, viscosity, volume factor and Z - factor) with pressure depletion during development. Fluid sampling, sample preparation and analysis for gas condensate reservoirs should conform to SY/T 5154 and SY/T 5543.

4.7.1.4 Properties of formation water, including water type, ion concentrations, total solids, density, pH value and trace elements, etc.

4.7.2 Pressure and temperature regimes

4.7.2.1 Describe the initial formation pressure and pressure gradient in each well - block of the gas reservoir. The initial formation pressure of

single well can be obtained by direct measurement or with well test method. Refer to SY/T 5440.

4.7.2.2 Determine the pressure regime of the gas reservoir on the basis of integrated static geologic characters, fluid properties, formation pressure, test production and inter - well interference data.

4.7.2.3 Initial formation pressure of a gas reservoir is such a value that is determined at a selected datum level on the cross plot of initial formation pressure at the depth halfway of the gas pay zone thickness vs. the depth for individual wells.

4.7.2.4 Pressure coefficient is calculated as the ratio of initial formation pressure to hydrostatic pressure at the same depth of the gas reservoir. Conform to SY/T 6168 for the Judgment of whether the gas reservoir is over - pressured, normally - pressured, or sub - pressured.

4.7.2.5 Describe the static formation temperature and geothermal gradient, and gas - well flowing temperature and flowing temperature gradient of the gas reservoir. Determine the formation temperature by way of direct measurement.

4.7.3 Fluid distribution

4.7.3.1 Describe the distribution of formation water within the gas reservoir. Determine the gas - water contact.

4.7.3.2 For gas reservoirs of various trap types but exhibiting a common hydrodynamic system, the gas - water contact is usually determined with the method of cross - plotting gas well and water well pressures based on the difference between gas pressure and water pressure gradients. Gas - water contact can be calculated using Equation (1):

$$D_{gwc} = \frac{(G_{Dw} D_w - G_{Dg} D_g)}{G_{Dw} - G_{Dg}} = \frac{(p_{wi} - p_{gi})}{\dots\dots\dots} \quad (1)$$

Where:

D_{gwc} —vertical depth of gas - water contact, in

meters (m);

D_g —vertical depth at halfway of the gas – producing interval, in meters (m);

D_w —vertical depth at halfway of the water – producing interval, in meters (m);

G_{Dg} —pressure gradient of the gas pay zone, in megapascal/m (MPa/m);

G_{Dw} —pressure gradient of the water – producing zone, in megapascal/m (MPa/m);

p_{wi} —initial formation pressure at halfway of the water – producing interval, in megapascal (MPa);

p_{gi} —initial formation pressure at halfway of the gas – producing interval, in megapascal (MPa) .

4.7.3.3 According to data available, gas – water contact can also be determined with the method of direct measurement of water saturation, of capillary pressure technique, of using the physical properties difference between gas and water, and of unsteady well testing.

4.7.3.4 Compose gas – water contact distribution map.

4.7.3.5 Analyze geologic factors controlling the distribution of gas, oil and water.

4.7.3.6 For the judgment of whether or not a gas condensate reservoir has an oil leg, conform to SY/T 6101.

4.8 Fluid flow characteristics of the gas wells and deliverability appraisal

4.8.1 Analysis of fluid flow characteristics

Analyze the fluid flow characteristics of the gas wells by using test data.

4.8.2 Gas-well deliverability appraisal

Analyze the deliverability of the gas wells and the influential factors, and evaluate the degree of improvement in bottomhole contamination after stimulation.

4.9 Type of the gas reservoir and drive mechanism

4.9.1 Type of the gas reservoir

4.9.1.1 Determine type of the gas reservoir according to type of the trap, morphological

configuration, poroperm type, fluid properties, oil – gas – water relationship, elastic energy and pressure coefficient.

4.9.1.2 For gas condensate reservoirs, the reservoir type is determined according to phase behavior of the fluids. In addition, the reservoir gas should be determined, on the basis of phase behavior studies, as to be rich or lean in condensate liquids. Method used should conform to SY/T 6101.

4.9.2 Drive mechanism of the gas reservoir

Determine the drive mechanism of the gas reservoir according to driving energy. Estimate the boundary, scale and energy of the water body and the coning of edge water and bottom water, and predict the activeness of the water body during production of the gas reservoir.

4.10 Static geologic model of the gas reservoir

4.10.1 Structure model

Describe the structural configuration and fault distribution of the gas reservoir.

4.10.2 Reservoir-bed model

Describe the architecture and structure of the reservoir bed and the spatial distribution of their attributes within the extension of the gas reservoir.

4.10.3 Fluid model

Describe the distribution of gas, oil and water and the distribution of physical and chemical properties of the fluids within the gas reservoir.

4.11 Reserve estimation and calculation

4.11.1 Volumetric reserve

Conform to DZ/T 0217 for the estimation of the volumetric reserve.

4.11.2 Dynamic reserve

Estimate dynamic reserve of the well block and of the gas reservoir the method of material balance.

4.11.3 Recoverable reserve

Conform to SY/T 6098 for the estimation of the recoverable reserve.

4.11.4 Reserve assessment

4.11.4.1 Assess the reliability of the data and

parameters used for calculation.

4.11.4.2 Perform comparative assessment of the reserves obtained by various methods.

4.11.4.3 Assess the spatial variation of reserve abundance.

4.11.4.4 Estimate the remaining reserve and the remaining recoverable reserve.

4.12 Predictive geologic model of the gas reservoir

4.12.1 Geologic reserve matching

Perform geologic reserve matching based on the numerical geologic model derived from grid – coarsen static geologic model.

4.12.2 Production history matching

The development indices to be matched mainly include production and cumulative production, gas/water ratio, and pressure.

4.12.3 Distribution of remaining reserve

After production history matching through numerical gas reservoir modeling, quantitative spatial – distribution field of the remaining reserve of the reservoir is obtained.

4.12.4 Predictive geologic model of the gas reservoir

Predictive geologic model of the gas reservoir is obtained by way of production history matching through numerical gas reservoir modeling on the static geologic model.

4.13 Exploitation potential of the gas reservoir

Analyze the distribution of current pressure and remaining reserve of the gas reservoir, and describe the exploitation potential of the gas reservoir.

5 Report on description results

5.1 Contents of the report

Contents of the report can be adjusted in terms of chapters and sections according to the objective of description corresponding to specific exploration and development stages. Things to be covered include: general information about the gas reservoir, stratigraphic characterization, structure characterization, description of sedimentary facies, fracture characterization, reser-

voir bed characterization, fluids – pressure – temperature characterization, fluid flow characteristics of the gas well and deliverability appraisal, type of gas reservoir and drive mechanism, static geologic model of the gas reservoir, reserve estimation, predictive geologic model of the gas reservoir, exploitation potential of the gas reservoir.

5.2 Appendices

The appendices include research report of detailed seismic data processing and interpretation and research report of detailed well – log data processing and interpretation.

5.3 Attached tables

The attached tables may include: Table of stratigraphic division data, Table of statistics of sampling and core analyses, Table of oil, gas and water shows, Table of basic drilling data, Table of collective test production data, Table of structure and fault attributes, Table of reservoir – bed and net pay data, Table of reservoir – bed correlation for single wells, Table of statistics of caverns from core observation, Table of statistics of fractures from core observation, Table of data of characteristic pore structure parameters, Table of measured porosity, permeability and saturation data, Table of collective criteria for reservoir grading and results of reservoir grading, Table of collective natural gas compositions, Table of collective formation water compositions, Table of collective condensates compositions, Table of data of natural – gas physical properties, Table of data used for volumetric reserve calculation, Table of gas well testing data, Table of gas – well production performance data, Table of data used for pressure – drawdown reserve calculation, Table of comparison between reserves of the gas reservoir calculated at different time.

5.4 Attached figures

The attached figures may include: Map showing geography, transportation and locality of the gas reservoir, Regional geologic structure map, Map

showing seismic lines and structure of the gas reservoir, Map showing exploration discoveries, Diagram of well log interpretation, Traverse and longitudinal cross sections of the gas reservoir, Graph of reservoir – bed correlation, Diagram showing pore structure characteristics, Composite column showing sedimentation and reservoir intervals, Map showing the spatial distribution of sedimentary facies, Isograms of porosity, permeability and gas saturation, Map showing spatial distribution of net pays, Map and cross section showing distribution of gas, oil and water, Curve showing the relationship between

pressure and altitudinal depth, Curve showing the relationship between temperature and altitudinal depth, Graph of well – test curve analysis, Graph showing pressure drawdown reserves, Phase diagram of fluids at different stages, Grid map for gas reservoir numerical modeling, Graph showing production history matching of gas wells, Isograms of reserve abundance of the gas reservoir, Map showing distribution of remaining reserve of the gas reservoir

Format of the figures should conform to SY/T 5615.