GCA Methodology for Calculating Reconstruction of Natural Gas Compressor Packages

Revision 01

April 1, 2011

The purpose of this guide is to help the reader gain a broad awareness and understanding of emissions regulations. Although derived from actual examples of applicability determinations made by the EPA, many of the concepts contained herein are subject to interpretation of the language and virtually no specific guidance has been provided, to date, by regulatory agencies with regard to the definition of reconstruction for natural gas compressors. Individuals should consult appropriate Federal, State and local agencies and regulations for definitive information, and submit applicability determinations for final determination.

NOTE: THE EPA HAS PROPOSED CHANGED TO THE NSPS RULE THAT MAY CONTRADICT THE HISTORICAL APPLICATION OF RECONSTRUCTION THAT IS THE BASIS FOR THIS DOCUMENT. FINAL RULE MODIFICATION IS EXPECTED SUMMER OF 2011. SEE RULE FOR DETAILS.

Introduction

Taking natural gas from the wellhead to mainline gas transmission markets involves a highly integrated infrastructure that has traditionally utilized natural gas fired reciprocating engines as the standard driver for natural gas compression. These engines are of a heavy duty, long life, industrial design that allows for periodic overhauls to maintain its design capabilities. With proper routine maintenance and periodic major overhauls, this equipment has been proven to have a life expectancy of 30+ years. Today there is compression equipment throughout the gas patch that was built in the 1960-1980's that is still operating successfully after multiple major overhauls.

Initially, many compressor packages were of a slow speed integral design, see Figure A.

Figure "A" – Integral Compressor

Integral compressors are built with the engine and compressor sharing major components such as frame, and crankshaft. It is very difficult to distinguish engine from driven equipment with such commonality of parts. Figure "B" shows a cut away drawing of an Ajax® compressor frame and cylinders.

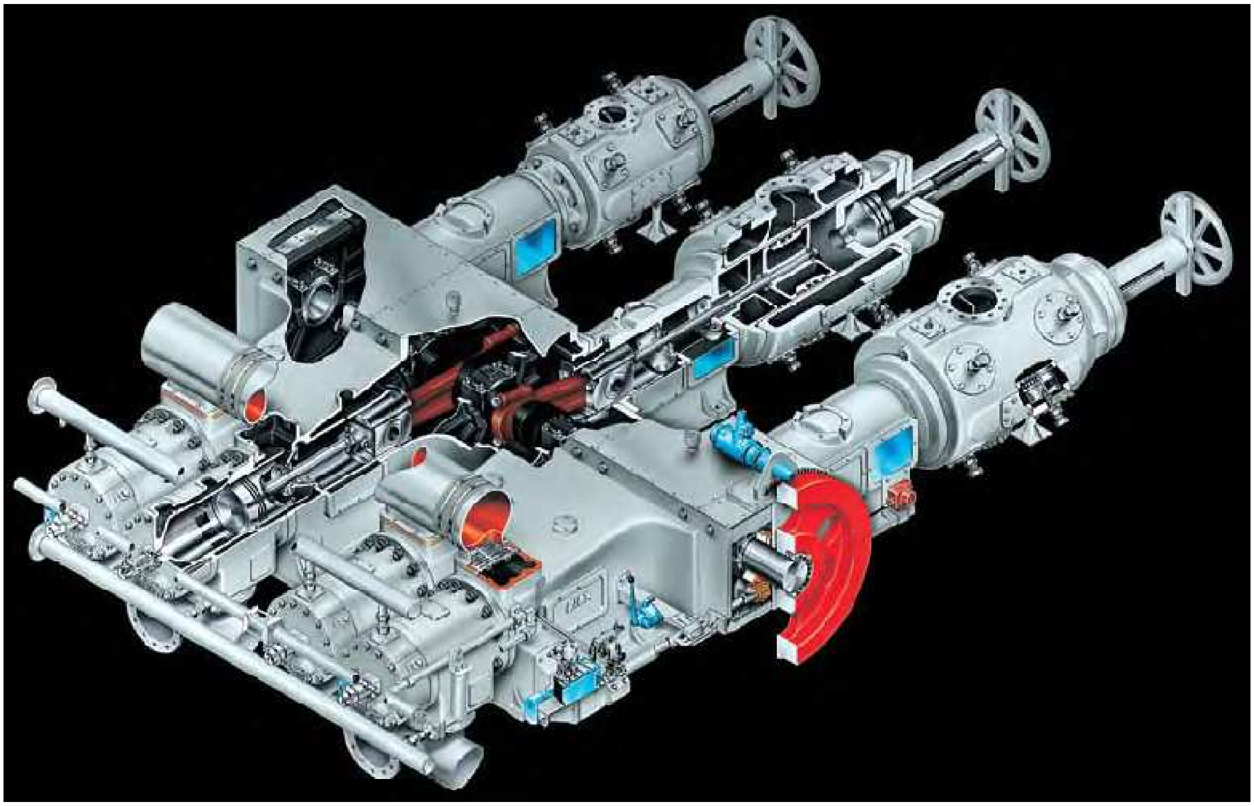

Figure B – Integral compressor frame and cylinders (engine power cylinders are on left and compressor cylinders on right)

Since the 1980’s the high speed separable compressor (see Figure “C”) has become the more commonplace design, although there are many integral packages in successful operation and a few models are still in production. The high speed separable compressor is the primary focus of this document because many of the concepts focus around the delineation between the engine and the driven equipment. This delineation on an integral unit is very difficult to discern and is outside of the scope of this document. Comments are included to help the reader determine whether a particular concept is applicable to an integral package and whether a different approach should be utilized.

The separable engine is commonly refurbished or relocated many times in its life, is normally installed on a structural steel skid with other major components, accessories, on-skid piping, controls, and alignment completed by an equipment manufacturer or packager. Skid mounting is by far the most common design used since it allows the unit to be shipped to the compression site as a complete package ready for installation.

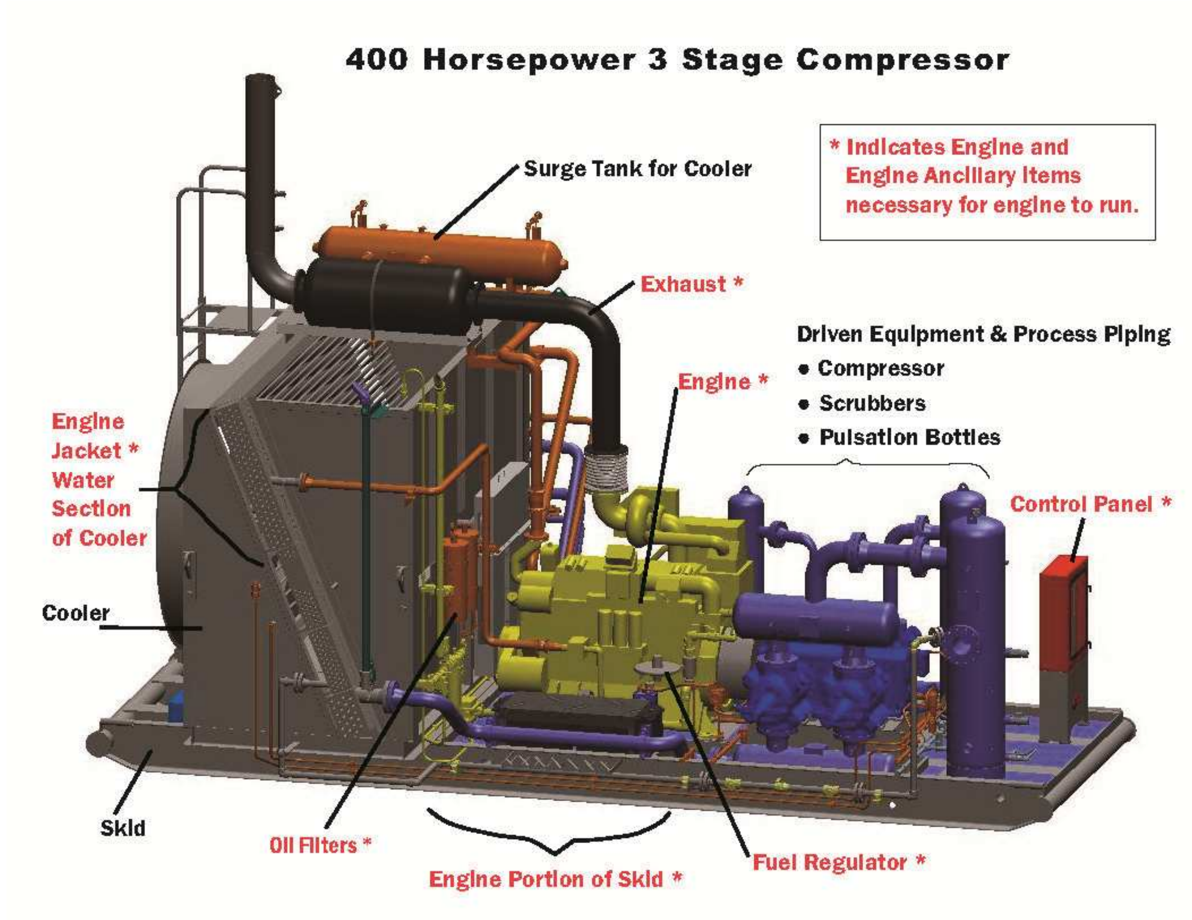

Figure "C" – Separable Compressor

Maintaining engine efficiency is crucial since most compressor applications, over a variety of operating conditions, produce gas flow as a function of maximum available engine horsepower. Since engine life is directly related to operation & maintenance practices, and fuel gas quality, the time between overhauls can vary from 2 years to 10 years. As engine performance deteriorates over time, companies must decide how to maximize its operating life without incurring a catastrophic failure.

An engine overhaul is a cost-based, event driven procedure that is generally not associated with engine modifications. Any maintenance decision concerning the type and scope of the engine overhaul is driven by many factors, including but not limited to:

- Engine design & type of wear or damage experienced
- Whether it is practical to remove the engine from site
- Time frame available to complete work
- Availability of parts
- Concurrent maintenance needs on other package components in addition to that required for the engine
- Site weather conditions
- Transportation and lifting accessibility constraints

This document has standard engine overhaul scenarios that demonstrate the details and complexities to be considered when performing engine reconstruction calculations.

Regulatory Background

The clean air act differentiates between a "new source" (also includes modified sources) and an "existing source". Generally speaking the existing sources are treated differently than new sources and usually have some regulatory advantage over new sources including being grandfathered from certain rules. This regulatory advantage translates into an economic advantage by not having to install and operate the same level of emissions controls as a new source. The time threshold for determining if a source was a new or existing source is usually the date of the proposed rule. [1] EPA did not want operators circumventing the law by rebuilding existing sources rather than replacing them at the end of their useful life with a new source. The logic the EPA used was that if enough money is spent on an existing source, it should be considered a new source and be subject to the same level of control as a new source.[2] Therefore, the EPA proposed a concept of "Reconstruction" in 40 CFR 60.15 that would treat a facility as a new source if certain thresholds were met. EPA states that the reconstruction provision will have "*little, if any impact on industries*" since industry does not use a minor part of a facility and replace the remaining portion.[3] Obviously, the concept of "reconstruction" does not fit very

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[1] In the proposed Standards of Performance of New Stationary Sources, the EPA gives us the background [Proposed rules page 36946*]…"Section 111 of the Act provides that the standards of performance established for new stationary sources reflect the degree of emission limitation attainable through the application of the best system of emission reduction, which considering cost, the Administrator determines has been adequately demonstrated. The Act further defines "new source" as "any stationary source, the construction or modification of which is commenced after the publication of regulations (or, if earlier, proposed regulations) prescribing a standard of performance under this section which will be applicable to such source". Thus, the standards apply not only to entirely new construction, but also to existing sources which undergo modification."*

[2] EPA stated in the final rule…*"The Agency's actual intent is to prevent circumvention of the law. Section 111 of the Act requires compliance with standards of performance in two cases, new construction and modification. The reconstruction provision is intended to apply where an existing facility's components are replaced to such an extent that it is technologically and economically feasible for the reconstructed facility to comply with the applicable standards of performance…As explained in the preamble to the proposed regulation, the purpose of the reconstruction provision is to recognize that replacement of many of the components of a facility can be substantially equivalent to totally replacing it at the end of its useful life with a newly constructed affected facility."*

[3] EPA statements in the proposed rule…*"Reconstruction of a facility which meets the specifications proposed under Section 60.15 constitutes new construction rather than modification. When a facility is completely replaced with a newly constructed affected facility, that facility is subject to the standards of performance. The purpose of the proposed provision is to discourage the perpetuation of a facility instead of replacing it at the end of its useful life with a newly constructed affected facility. It should be recognized that it is generally the practice of the industries currently covered by standards of performance to close an old existing facility rather than to reconstruct it by using a minor part of it and replacing the remaining portion. Because of this, the proposed provision will have little, if any impact on industries currently covered."*

well with reciprocating internal combustion engines that are overhauled routinely as part of an expected life of 30 years or more by replacing components that are designed to wear. However, Owners and Operators are still required to comply with this law. This document will compare the historical application of reconstruction with general industry practices.

Reconstruction is a two part test, both of which must be satisfied:

1. The fixed capital costs of the new components (amount spent) must exceed 50% of the cost of a comparable entirely new facility.
2. It must be technologically and economically feasible for the reconstructed source to meet the relevant standard.

The first test is a numerical calculation to see if the reconstruction costs exceeded 50% of the cost of a new facility. The reconstruction equation used to do the calculation is the dollars spent on the overhaul (the Numerator) divided by the cost of comparable entirely new facility (the Denominator). Although the calculation is very straightforward, the challenge lies in determining the most accurate numerator and denominator.

Reconstruction Equation:

$$\frac{\text{Fixed Capital Costs of the New Components}}{\text{Cost of a comparable entirely new facility}} = \text{\% Reconstruction}$$

This document provides some industry accepted guidance to define and estimate these items as they relate to **Natural Gas Fueled Spark Ignited Internal Combustion Engines on skid mounted compressor packages (NGF-SI-RICE-Comp).** If the 50% threshold is exceeded, then the data should be submitted to the agency as further described in 40 CFR 60.15 **at which time the agency will determine if the 2nd test is met.** In order to facilitate the reconstruction analysis, certain steps must be accomplished:

Step #1 – Define the “affected facility”

Step #2 – Apply the concept of “pro-rating” costs of components that support both the affected facility and other processes.

Step #3 – Define basis to use for pricing (retail vs. wholesale transactions, timing issues)

Step #4 – Develop standard cost “adders” to be applied to represent components of the affected facility if specific information is not available. The Owner/Operator is free to use more specific data if it is known. This adder will be in the form of $/hp and varies based on horsepower class.

Step #5 – Develop a methodology to estimate installation and start up costs for the affected facility.

Step #6 – Identify which items should be used in the numerator and denominator for different types of overhauls.

Steps #1 through #5 deal primarily with estimating the "comparable new facility" which is the denominator of the reconstruction equation. These items provides tools and generic factors to enable the Owner and Operator to make an engineering level estimate of what a new facility would have cost, had it been built in lieu of overhauling the existing facility.

Step #6 deals primarily with what costs are appropriate to include in the numerator of the reconstruction equation but also provides additional information regarding the costs in the denominator. These costs vary, depending on the particular scenario utilized in the overhaul process.

This document was created based on examples previously given by the EPA in determining applicability as it relates to 40 CFR 60.15. The following applicability determinations were used:

- Control # NB28 dated 11/25/86
- Control # 0200048 dated 9/3/99
- Control # 9800085 dated 5/11/98
- Control # 9900057 dated 04/23/98
- Control # 0800031 dated 2/28/08 (not a completed Determination but has a good discussion)

The above applicability determinations can be found at: EPA Applicability Index . To find the above determinations, type the control number into the word search box or search by date range.

Step #1: Define the "affected facility"

The individual components to be included in the calculation are restricted to those depreciable components that are part of the affected facility as defined in the relevant subpart. The relevant subpart for the purpose of this discussion is Subpart JJJJ of 40 CFR Part 60. Below are some examples of how the facility is defined for other subparts:

- NSPS subpart KKKK - The affected facility is each stationary combustion turbine, defined as follows: Stationary combustion turbine means all equipment including but not limited to the turbine, the fuel, air lubrication and exhaust gas systems, control systems (except emissions control equipment), heat recovery system, and any ancillary components and sub-components comprising any simple cycle stationary combustion turbine, any regenerative/recuperative cycle stationary combustion turbine, any combined cycle combustion turbine and any combined heat and power combustion turbine based system.
- Subpart ZZZZ- The "affected source" is defined as a stationary RICE (Reciprocating Internal Combustion Engine). Driven equipment was further clarified as not included as part of the affected facility in EPA Memorandum dated 9/30/05 from Michael S. Alushin. See http://www.epa.gov/ttn/atw/rice/riceq_a_9-30-05.pdf

For Subpart JJJJ, the “affected facility or source” is not defined within the regulatory language. Subpart JJJJ only references SI ICE (Spark Ignited Internal Combustion Engines). Since SI ICE can provide power to any number of different process/driven equipment, the affected facility is limited to the engine itself and the ancillary components necessary for it to run. By this definition the regulatory status follows the engine, not the “whole compressor package”. In the event of an engine swap, the NSPS status would be dependent on the replacement engine and could therefore change. This is somewhat contrary to the concept used for most air permits which are defined by the “site” which could include multiple sources such as compressors, dehydrators, vents, and fugitive emissions.

The term "fixed capital cost" is described in the December 16, 1975 preamble to the Standard of Performance for New Stationary Sources. The preamble states, *“ The term “fixed capital cost” is defined as the capital needed to provide all the depreciable components and is intended to include such things as the costs of engineering, purchase and installation of major process equipment, contractors’ fees, instrumentation, auxiliary facilities, buildings, and structures. Costs associated with the purchase and installation of air pollution control equipment (e.g., baghouses, electrostatic precipitators, scrubbers, etc.) are not considered in estimating the fixed capital cost of a comparable entirely new facility unless that control equipment is required as part of the process (e.g., product recovery).”*

Further clarification is provided in previous applicability determinations that the EPA has done:

1) Buildings are excluded on several occasions when they house other items that are not part of the affected facilities. In control # 0800031, the EPA States, “care should be exercised to include only those costs associated with the existing facility and the reconstructed affected facility; therefore, costs associated with the depreciable components that are listed in the preamble, such as buildings, should only be included in your reconstruction calculation if they are part of the existing facility…as defined in [the subpart].” No provision for pro-rating the building is mentioned. In the case of NGF-SI-RICE-Comp, the building housing the compressor package would generally not be included in calculation except in unusual cases which would need to be evaluated case by case.
2) Related process systems such as water supply system for steam generation are not included except for attachment points.
3) Turbogenerators (equivalent of driven equipment) are not included.
4) Auxiliary systems such as fire protection can be included to the extent they directly service the affected facility (see control # 9800085)
5) Newer versions of affected facilities with added pollution control equipment cannot include the cost of the added equipment. Example Cat 3306B engine which will include AFR and Catalyst cannot be compared to older engines. (See Low NOx burner example on Control # 0200048). Unless the original form is not longer available.
6) For stationary combustion turbine (subpart KKKK) see also Control # 0800031 states that the following components are part of the affected facility: turbine, fuel, air, lubrication and exhaust systems, control system and any ancillary components. Stationary combustion turbines have

many similarities with NGF-SI-RICE-Comp's. Drawing Parallels to the above for a NGF-SI-RICE-Comp package gives an indication of what components to include:

a. Included Items
    i. Turbine (KKKK) is equivalent to RICE for NGF-SI-RICE-Comp's
    ii. Fuel System (KKKK) is equivalent to carburetor, fuel scrubbers and regulators for NGF-SI-RICE-Comp's
    iii. Air System (KKKK) is equivalent to air filter housings for NGF-SI-RICE-Comp's
    iv. Lubrication (KKKK) is equivalent to oil coolers and oil tanks tied to engine for oil automatic oil make-up for NGF-SI-RICE-Comp's. Off skid tanks solely for storage would not be included
    v. Exhaust system (KKKK) is equivalent to muffler and exhaust piping for NGF-SI-RICE-Comp's. *Note: emission controls such as catalyst are not included as part of the facility.*
    vi. Control system (KKKK) is equivalent to control panel and wiring for NGF-SI-RICE-Comp's. Note: Air to Fuel ratio *controllers (AFR's) would be included if part of engine design. AFR's installed just for non selective catalytic controls would not be included since they are part of emissions controls.*
    vii. Other items (KKKK) are equivalent to water jacket cooler, skid support, catwalks and ladders for NGF-SI-RICE-Comp's if they are for the engine and not driven equipment.
b. Not Included
    i. Land, roads and site preparation
    ii. Demolition of old package or removal of old engine if it is not reinstalled
    iii. Driven equipment such as compressor
    iv. Process piping and equipment not directly serving the engine. This would include scrubbers, suction, discharge and inter-stage piping.
    v. Heat exchangers (after coolers) associated with driven process (portion of cooler not associated with jacket water or Turbo Aftercooler).
    vi. Monitoring equipment such as SCADA, alarms, etc…

7) Pollution control equipment is NOT included in the cost of the facility. See preamble to construction regulations dated December 16, 1975.
8) Some on-site items would be included. This could include fuel systems and meters. (Note: fuel meters are necessary to perform some of the emissions tests). It could also include lubrication systems. These systems may need to be pro-rated to each engine (see below).
9) Site installation costs. These vary from site to site and with make and model of compressor package but are relatively constant within a horsepower class. EPA cost control manual states that Direct Installation costs are typically factored from the purchased equipment cost (PEC), but no range of factors is given. (See Footnote (b) on Figure 2.2 of EPA Cost Control Manual). Typical assumptions by the EPA utilized in installation of pollution control equipment are 30% for Direct Installation and 31% for Indirect Costs. Using the combined 61% of the PEC would

yield a result that is unrealistically high. Step #5 includes a discussion on how to estimate these costs.

10) Start up costs. These vary from site to site and with make and model of compressor package but are relatively constant within a horsepower class. These costs include alignment, testing, adjusting settings such as timing and fuel. Care should be exercised to not include start up costs for items not directly associated with the engine such as driven equipment. EPA Cost Control Manual states that Indirect Installation costs which include start up costs are typically factored from the purchased equipment cost (PEC), but no range of factors is given. (See Footnote (b) on Figure 2.2 of EPA Cost Control Manual). Step #5 includes a discussion on how to estimate these costs.

Figure "C" above shows some of the components of a *separable* NGF-SI-RICE-Comp. Those components that are part of the affected facility are indicated in red and noted with an asterisk.

Note for Integral Compressors: It is very difficult to distinguish the engine from the driven equipment on an integral compressor package due to the sharing of major components. Therefore, most Owners and Operators define the entire package as the facility and since these packages are still in production, a replacement cost is relatively easy to establish. If the entire package is considered the facility, then all costs associated with an overhaul (including compressor overhaul) must be included in numerator of the reconstruction equation for each "overhaul event". If only the costs associated with the "engine portion" of the overhaul are included, then the cost of a new package must be delineated into an "engine portion" and "driven portion" as well, with only the engine portion utilized in the denominator. Either method would be acceptable, but are outside the scope of this document.

<u>Step #2: Apply concept of pro-rationing components (Separable Packages)</u>

Several of the ancillary components that directly service the engine and are necessary for it to run also service driven equipment. The cost of these components should be included in the affected facility but only partially. The amount included should be representative of the amount of the component that directly services the engine and is necessary for the engine to run. In many cases this is a conservative approach as there are economies of scale realized by combining duties on these components. GCA member companies that package natural gas compressors provided technical data which was used to determine the portion of various components that are engine related. Below are the major components that should be pro-rated and the appropriate percentage to include that is engine related :

- Skid: The skid serves as the mounting support and foundation for the engine. Without the skid, the engine would not stay upright and would not be able to transfer power to any driven equipment. However, the skid is also the foundation for the entire compressor package which includes the driven equipment (compressor) and its related piping and vessels, and in some cases the cooler.

- **Percent to include: 25%**
- Basis for percentage: The amount of the skid supporting the engine was derived by taking measurements from engineering drawings of the linear distance of the skid underneath the engine divided by the total length of the skid. The percentages were:
    - 95 Horsepower, 3 stage = 20-28%
    - 145 Horsepower, 3 stage = 24%
    - 195 Horsepower, 3 stage = 25%
    - 400 Horsepower, 3 stage = 20-26%
    - 670 Horsepower, 3 stage = 20-24%
    - 1340 Horsepower, 3 stage = 24-27%

  Note that the above percentages only include the portion of the skid supporting the actual engine. An additional portion of the skid supports the cooler which in turn has an engine related component. Also of note is that the driven equipment (compressor) on all of these packages was a 3 stage reciprocating compressor. A two stage, single stage or rotary screw package would have less driven equipment surface area and would have a higher percentage that is engine related. Based on the above, the assumption of 25% of the skid is a conservative assumption.

- Cooler: The cooler is comprised of several parts. There is a shell, a fan, and exchanger sections that are used to cool different streams. The shell and fan support all of the exchanger sections.
    - **Percent to include = 40%.**
    - Engine Water Jacket Section – Provides the heat rejection that the engine needs to run, similar to a radiator on an automobile. Without the engine water jacket section, the engine would not be able to run. The engine jacket water section should be included in the fixed capital costs of the affected facility.
    - Turbo Aftercooler – (applicable to turbocharged engines only) provides cooling for the intake air after it is compressed by the turbocharger prior to entering the engine for combustion. The turbo aftercooler section should be included in the fixed capital costs of the affected facility. Horsepower rating of the engine is directly affected by this section.
    - Gas aftercoolers – These sections cool the natural gas after it is compressed. There is typically one aftercooler section for each "stage" of compression. These do not directly service the engine and would not be necessary for the engine to run. The aftercooler(s) should not be included in the fixed capital costs of the affected facility.
    - Methodology - The range of percents varies by design and engine type and the overall range was 26-50% of the cost of the cooler (see Table below). The percentage of the total cooler cost was evaluated on different size engines using various methods.
        - Method #1: The Cost of Cooler for only the engine divided by cost of combination cooler for engine and driven equipment.

- Method #2: Ratio of Surface area. Surface area ratio of engine section divided by surface area of entire cooler.

- Table 2 shows some examples of coolers and the percentage that is engine related by using Method 1 vs. Method 2

Table 1: Percentages of Coolers that are engine related

	Type of Compressor (Reciprocating or Screw)	Method #1 (stand alone cooler percentage of combination unit)	Method #2 (square footage ratio)
95 HP (CAT 3304 NA)	Reciprocating 3 stage		29%
145 HP (CAT 3306 NA)	Reciprocating 3 stage	47%	37%
195 HP (CAT 3306 TA)	Reciprocating 3 stage	44%	45%
256 HP (Cummins GTA855E)	Rotary Screw	40%	
400 HP (Waukesha F18GL)	Reciprocating 3 stage	43%	43%
670 HP (CAT 3508 TALE)	Reciprocating 3 stage		38%
1340 HP (CAT 3516 TALE)	Reciprocating 3 stage	44%	50%
1340 HP (CAT 3516 TALE)	Reciprocating 3 stage		43%

- Control Panel and on-skid wiring: The control panel contains gauges and shut down devices that monitor engine performance as well as performance of the driven equipment. Although the primary function of the panel is monitoring and control of the driven equipment and processes, which should not be included in the fixed capital cost of the (engine) facility, there is a small portion of the panel board that services the engine should thus be included. Since the panel is often priced as one unit, it must be pro-rated.
  - **Percentage to include: 7.5%**
  - Methodology – Engineering estimate of the portion of the control panel and wiring that is directly related to the engine.
- Packaging Labor: The method for accounting for labor to assemble a natural gas compressor package varies by packager as well as by package type. The packagers typically purchase the major components such as engine, compressor, and cooler from third party vendors. In some

instances, the skids may be outsourced as well. These components are then assembled on the skid along with the remaining items such as control panel , exhaust system, fuel system, piping, wiring, etc. Some packagers create sub assemblies of these other components while others account for all of the labor under one cost code. Regardless of the accounting method, the labor utilized to install the engine and its ancillary systems should be included in the fixed capital cost of the affected facility whereas the labor for installing the driven equipment and its piping should not be included.

  - Percentage to include: Varies by packager. Each packager estimated the cost per horsepower by horsepower class.
  - Methodology – Estimates from packagers of the percentage of labor utilized to install the engine and engine ancillary items during fabrication.

- Fuel, Exhaust and Oil Systems: These systems vary in scope and size depending on the packager, but most are included to some degree.
  - **Percentage to include: 100%**
  - Methodology – These ancillary systems only support the engine (not driven equipment) and are necessary for the engine to run, therefore all of the costs for these systems are included as part of the facility.

<u>Step #3 – Pricing Considerations</u>

The "cost" of an engine can vary significantly depending on the purchaser and the terms under which it is purchased. Packagers/equipment manufacturers who purchase large quantities of engines are often given wholesale or industry based variance discounts by the engine manufacturers or their distributors. The packagers do not compete with the distributors in sales of new engines to end users (Owners and Operators). The packagers/equipment manufacturers are only allowed to re-sell these engines as part of a completed compressor package which would include a mark up above their cost. This mark up is applied to all of the components of the package including the engine, compressor, piping, labor etc…The same engine, if purchased individually, would cost more.

Deliverability plays a role in the pricing as well. In recent past, the demand for engines exceeded supply and engines were ordered up to twelve months in advance. The same engine, if needed immediately was sold at a higher price. The basis to use as the price has a large effect on the cost of a "comparable entirely new facility". **<u>The cost of the engine should be reflective of a Fair Market Value of an engine without discounts associated with volume buying and/or discounts given to packagers/equipment manufacturers.</u>** In most cases the manufacturer's suggested retail price is the closest estimation of the Fair Market Value. This pricing assumption would even out wholesale and industry based variance discounts given to packagers/equipment manufacturers based on volume purchases and would eliminate the inflated premium placed on an engine with a short delivery time. Note that this price changes every year for each model of engine and the current price should be applied at the time of the overhaul. The cost of the engine is usually obtained by getting a quote from an engine distributor.

Similar to engine cost, the cost used to estimate the ancillary items should be representative of a retail (fair market value) transaction as opposed to a discounted cost from the packager/equipment manufacturer. The retail price represents the cost of the finished product as it is utilized by the Owner and Operator. The fair market value of the ancillary items was calculated by the packagers by multiplying the wholesale cost basis (in 2009) for the materials and labor to construct the ancillary items by their actual sales margin for the two prior years (2007 and 2008). This gives the best representation of the cost of the ancillary items as used by the Owner and Operator.

Adjustment of costs for time to reflect historical and future values. (All costs for the analysis need to be adjusted to reflect the value at the time of the overhaul[4]).

The cost of a comparable new facility should be reflective of the cost at the time of the overhaul. For example, an overhaul done in 2007 (with 2007 "dollars" should be compared to the cost of the comparable new facility as it would have cost ***at the time of the overhaul*** (2007 in this example). Since all of the cost data for the ancillary items is based on "2009 dollars", these ancillary costs should be adjusted to the time frame that the engine was overhauled. Similarly, a quote for a new engine in 2009 would need to be adjusted to represent what that engine would have cost in 2007. The cost is adjusted by using the Producer's Price Index (PPI). The recommended PPI for adjusting compressor related items is the PPI for Pumps, Compressors, and Equipment (Commodity Code 11-41). For convenience, the PPI for 2006 through 2011 are included in Table 2 below[5]. Future PPI's can be found at the following website - http://www.bls.gov/news.release/ppi.t02.htm

Table 2: PPI Indexes

Commodity 11-41: Pumps, Compressors and Equipment	
Year	PPI
2006	185.3
2007	195.4
2008	207.3
2009	212.6
2010	214.8
2011	221.2 (estimate)

[4] Note: Since the reconstruction analysis is a calculated percentage, this process only requires that all of the costs be adjusted to the same point in time. For simplicity, the time of the overhaul is the easiest time because the overhaul costs are already at that point in time and therefore need no further adjustment for those costs.

[5] PPI's are published monthly. The above PPI's are for July of the year indicated. The PPI for 2011 is assumed to be 3% increase over 2010.

As part of the research for this document, three natural gas engine manufacturers were polled to provide the percentage increases on their engines during the same time frame. The average increase for the engines was 4.8% per year which is consistent with the above PPI indexes.

Step #4 – Develop standard Cost Adders to represent ancillary equipment that is part of "Affected Facility"

A factor based on dollars per horsepower ($/HP) was developed to estimate the cost for ancillary items. This factor, when multiplied by the horsepower of the engine, provides a reasonable estimation of the cost of the ancillary items necessary for the engine to run. The values were determined based on cost studies by OEM packagers. The technology and design of the ancillary items is consistent across the industry so using a standard or typical cost for these items gives a reasonable estimation for this portion of the comparable entirely new facility. If more specific information regarding a particular model is available, that data can be used in lieu of the standard cost. Because the cost per horsepower varies some with size of the unit, the OEM packagers provided data for the following horsepower classes:

- Under 100 horsepower
- 100 to 199 horsepower
- 200 to 499 horsepower
- 500 to 999 horsepower
- 1000 to 1750 horsepower

The cost of the ancillary items was provided for each of the components and pro-rationing was applied as discussed in Step #2 above generating a single value in dollars per horsepower for each size range. This value can then be used to estimate the cost of the ancillary components by multiplying the value by the horsepower of the engine being evaluated.

Step #5 – Develop a methodology to estimate site installation, start-up, and commissioning

The site installation, start-up, and commissioning costs are part of a new facility and cover items such as trucking, cranes, labor, materials, testing, commissioning, etc. The cost included in the new facility should only be those associated with the engine and its ancillary components and do not include installation of driven equipment such as connecting suction and discharge piping. The costs for the installation, start-up and commissioning of the engine and ancillary items can be estimated by using generic factors or by doing an estimate on a case by case basis.

Option #1 – Use generic cost factors

A factor based on dollars per horsepower ($/hp) was developed to estimate the typical cost associated with the installation and commissioning of the engine. This factor, when multiplied by the horsepower of the engine, gives a reasonable estimation of the installation, start-up and commissioning costs. Individual components of the factor were pro-rated by the percentage that is applicable to the Affected Facility. The pro-ration of the components ranges from 0 to 100% depending on the component. For example, installation of the process piping (suction and discharge lines) is 0%, while commissioning of the engine is 100%. The generic factor for installation, start-up and commissioning varies by horsepower class (size) using the breakdown below:

- Under 100 horsepower
- 100-199 horsepower
- 200-499 horsepower
- 500-999 horsepower
- 1000-1750 horsepower

  Appendix "D" lists the assumptions for the generic factors by horsepower class. For simplicity, only the components that had an engine pro-ration percent greater than zero were included.

Option 2 – Estimate costs on a case by case basis

For the purposes of the reconstruction analysis, it is a reasonable assumption that the start up and commissioning costs for a comparable entirely new facility would be *at least* the same as the same as the start up and commissioning costs associated with the overhaul with the exception of emissions testing. Since a "new facility" would by definition be subject to the NSPS rule, there would be an initial compliance test required. This test would cost between $2,000 and $5,000 depending on horsepower and location of engine (under 100 horsepower does not require testing for volatile organic compounds (VOC's) and remote engines have higher mobilization costs). One option for estimating the cost is to use the installation, start up and commissioning costs associated with the overhaul as a conservative estimate of the same costs of the new facility and then add the cost for the emissions test which would be required of a new facility.

<u>Step #6 – Identify items to be included in the Calculation when overhauling an engine</u>

When performing a reconstruction analysis there are general principals which should be followed:

- The regulatory status follows the engine, not the compressor package. Include appropriate costs that are associated with the engine that will be operated by the Owner & Operator *after* the overhaul. The engine operated after the overhaul could be either the same engine or a replacement engine.

- Appendices "A" and "B" include more detailed descriptions of the various overhaul scenarios and what to include. There are 4 common scenarios based on type of engine/compressor, whether the engine was removed or overhauled in place and whether the engine was replaced with different engine. The 4 scenarios are:
  Scenario 1: An engine on a ***<u>separable</u>*** compressor is rebuilt on site.
  Scenario 2: An engine on an ***<u>integral</u>*** compressor is rebuilt on site.
  Scenario 3: An engine is removed, overhauled and reinstalled.
  Scenario 4: An engine is removed and a different replacement engine is re-installed.

- Items like engine removal may or may not be included depending on whether the same engine is re-installed.

    a. If the same engine is re-installed, then the removal costs would be part of the overhaul event

    b. If the engine is replaced with a different engine, as in the case of a swing engine, then the engine of concern is the replacement engine, not the original engine which was removed. Do not include costs associated with the removal of the original engine. Those costs would not be part of the reconstruction analysis of the replacement engine.

- Reconstruction analysis is an event driven process. The costs are not cumulative over any time frame other than the logical beginning and end of the event. For example, if a top end overhaul is completed on an engine and a month later, the engine experiences a failure and has to be completely overhauled, then the complete overhaul is a second event and would be evaluated separately. The costs from the first top end overhaul would not be included in the reconstruction analysis of the full overhaul. However, the costs cannot be broken into "stages" for the purpose of circumventing reconstruction.

Summary

Major points covered in this document and the appendices are:

- The reconstruction analysis is performed by dividing the cost spent on the overhaul (numerator) by the cost of a comparable entirely new facility (denominator). If the ratio is over 50%, then the data should be submitted to the regulatory agency for an applicability determination.
- The facility includes the engine, the ancillary items necessary for it to run, and the installation, start-up and commissioning costs (See Step 1).
- Components of the facility that service both the engine and the driven equipment should be pro-rated for the engine portion. For natural gas compression packages, these include the skid, cooler, panel and controls and packaging labor. (See Step 2).
- Pricing should be reflective of a Fair Market Value or retail transaction and should be adjusted to reflect the time the money was or would have been spent (See Step 3).
- The ancillary items for separable compressor packages can be estimated using generic dollars per horsepower ($/hp) factors (See Step 4).
- The installation, start-up and commissioning costs for separable compressor packages can be estimated using generic dollars per horsepower ($/hp) factors (See Step 5).
- Care should be exercised to maintain consistency in determining costs. What costs to include varies by type of engine and type of overhaul (See Step 6).

Table 3, below, represents the factors for estimating the Ancillary Items and Installation, Start-up and Commissioning costs (on a $/hp) basis for various horsepower ranges of engines. These factors are in 2009 prices and only apply to separable gas compression packages. These factors can be used if model and/or case specific estimates are not available and will yield a good estimation of the costs associated with the ancillary items and the installation, start-up and commissioning of separable **NGF-SI-RICE-Comp's**.

Table 3 – Summary of factors for estimating Ancillary Items and Installation, Start-up and Commissioning Cost (Based on 2009 values)

Horsepower Range	**Ancillary Items ($/HP)** • **Cooling system** • **Skid** • **Fuel/Start system** • **Controls (except emissions controls)** • **Labor to package** • **Oil system** **Note: above pro-rated for engine related portion only**	**Installation Costs ($/HP)** • **Trucking** • **Cranes** • **Hookup Labor & Parts** • **Commissioning** • **Emissions testing** • **Connection of Fuel and start gas** **Note: above pro-rated for engine portion only**
Under 100 HP	$231 per horsepower	$48 per horsepower
100 to 199 HP	$169 per horsepower	$43 per horsepower
200 to 499 HP	$117 per horsepower	$21 per horsepower
500 to 999 HP	$114 per horsepower	$15 per horsepower
1000 to 1750 HP	$78 per horsepower	$11 per horsepower

NOTE: Values above are based on costs in 2009 and must be adjusted to the time of the overhaul using PPI Indexes in Table 2.

The denominator for the analysis is equal to the replacement cost of an entirely new comparable facility which is:

Retail Price of Replacement Engine + Ancillary Items + Installation, startup and commissioning

Where:

- Retail Price of Engine =
  - obtained from Engine Manufacturer or Distributor
  - If necessary, price can be adjusted to a different model year using the PPI adjustments in Table 2.
  - If the specific engine model is no longer in production, then a price for a comparable engine can be used.[6]

- Ancillary items =
  - (horsepower of engine) * ($/hp for Ancillary Items from Table 3), or
  - Model specific engineering estimate
  - If necessary, costs can be adjusted to a different year by using the PPI adjustments in Table 2.

- Installation, start-up, and commissioning =
  - (horsepower of engine) * ($/hp for Install, start-up, and commissioning from Table 3), or
  - Case specific estimation
  - If necessary, costs can be adjusted to a different year by using the PPI adjustments in Table 2.

Appendix "C" includes some sample calculations of reconstruction. In all cases, the regulatory agency has the final decision regarding whether or not a facility has been reconstruction, and the Owner and Operator should request an applicability determination by the appropriate state or federal agency if they believe that the facility has been reconstructed.

[6] A comparable engine would be one of similar design and construction (i.e. industrial grade) that produces the same horsepower at a comparable speed (RPM) or an engine of the same displacement. .

Corrections and Comments should be sent to the attention of the

HSE Committee Chairman of the GCA

Via email to:

info@gascompressor.org

List of Appendices

Appendix "A" – Storyboard of overhaul scenarios

Appendix "B" – Matrix of Numerator and Denominator content

Appendix "C" – Sample Calculations

Appendix "D" – Assumptions used for Installation, Startup and Commissioning factors

Appendix A

to

GCA Methodology for Calculating Reconstruction of Natural Gas Compressor Packages

“story board” for engine replacement method & associated major steps

Revision 03

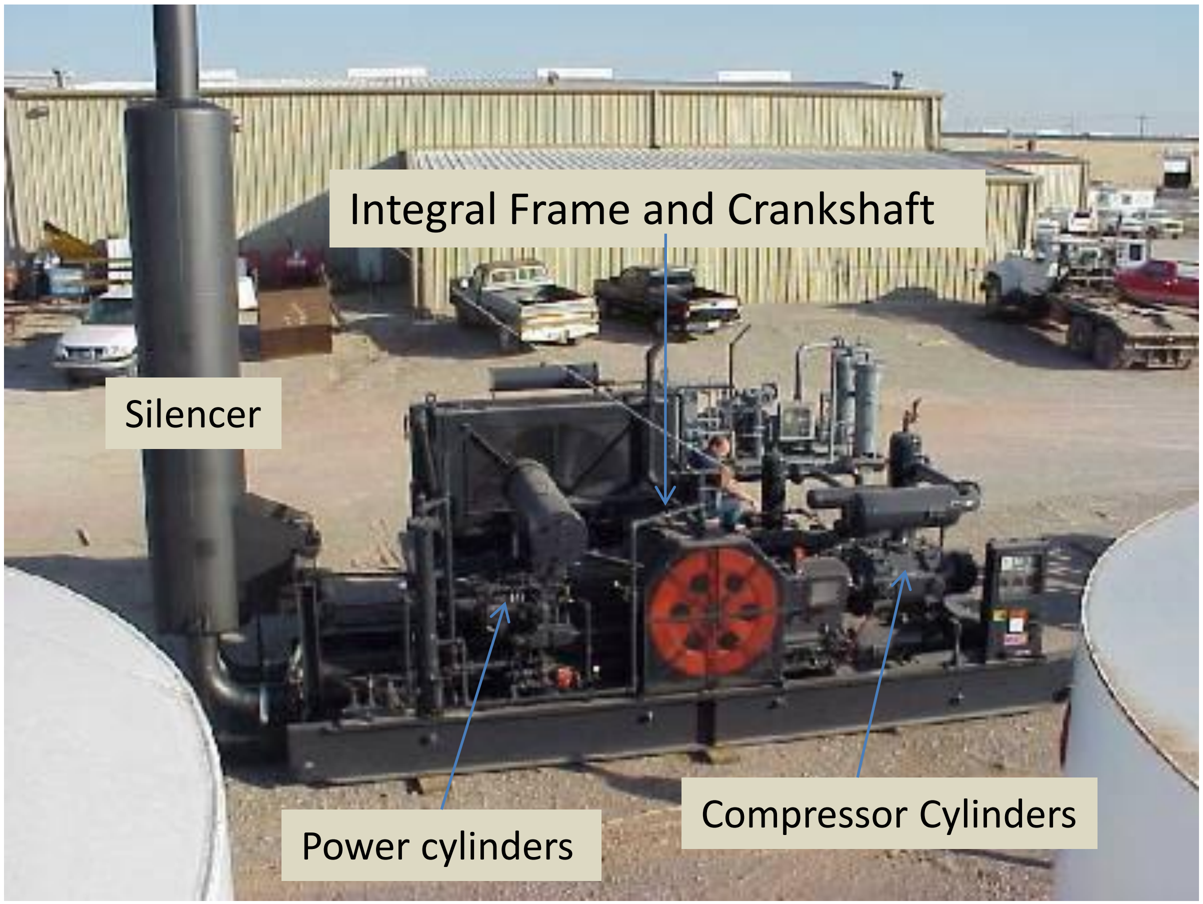
Introduction:
Basic Types of Gas Compressor Packages

Integral

Separable

Integral Compressor Details

Power cylinders typically repaired on site.

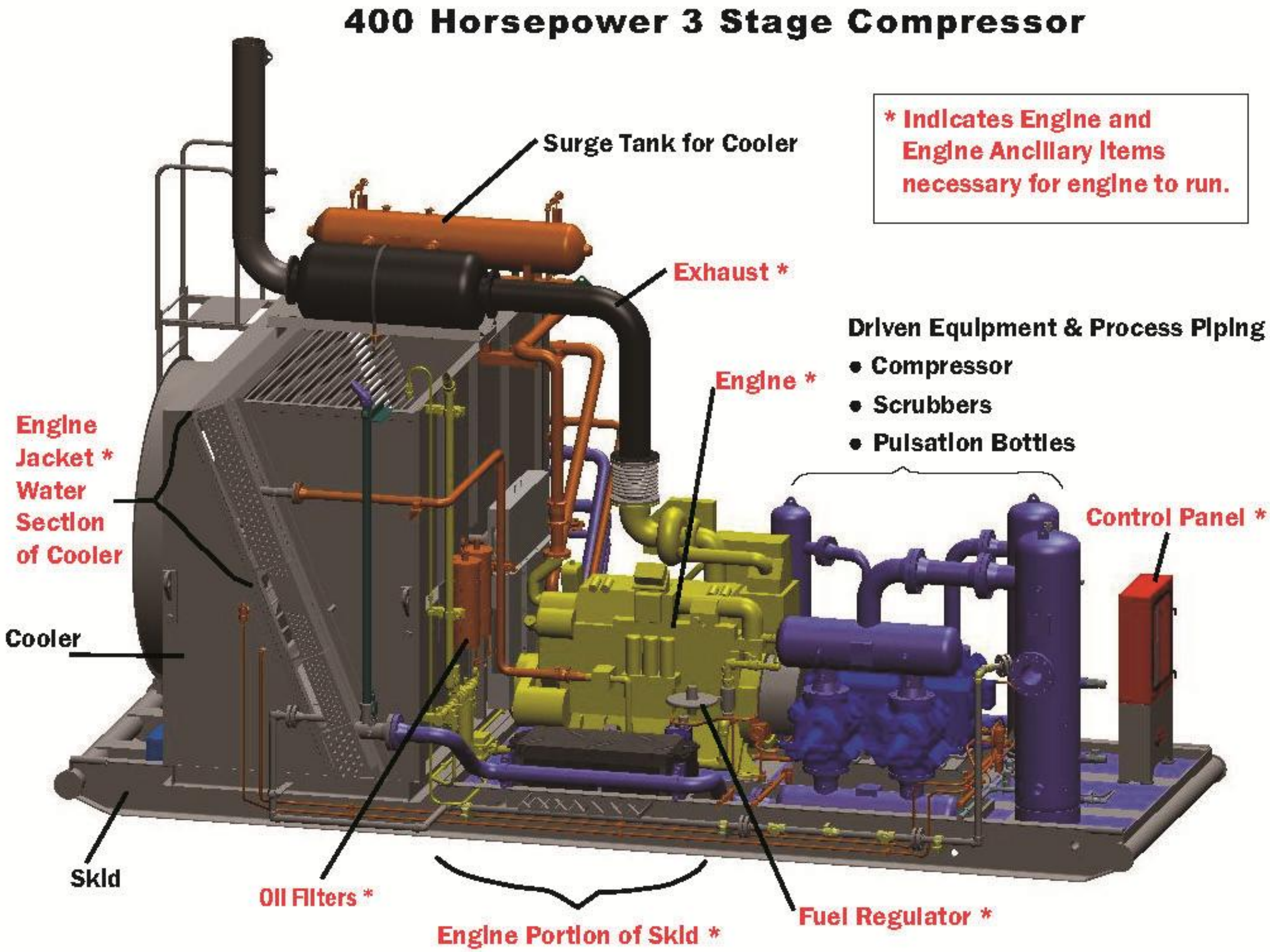


Separable Gas Compressor Packages On-Site

Engine is removable for repair or exchange, but can also be overhauled on site.

Separable Compressor Details

Facility includes engine and ancillary items shown.



If Engine Renewal is Required

- Worn or damaged engine replacement requirement identified.

- Requirement determined by inspection, records and performance.

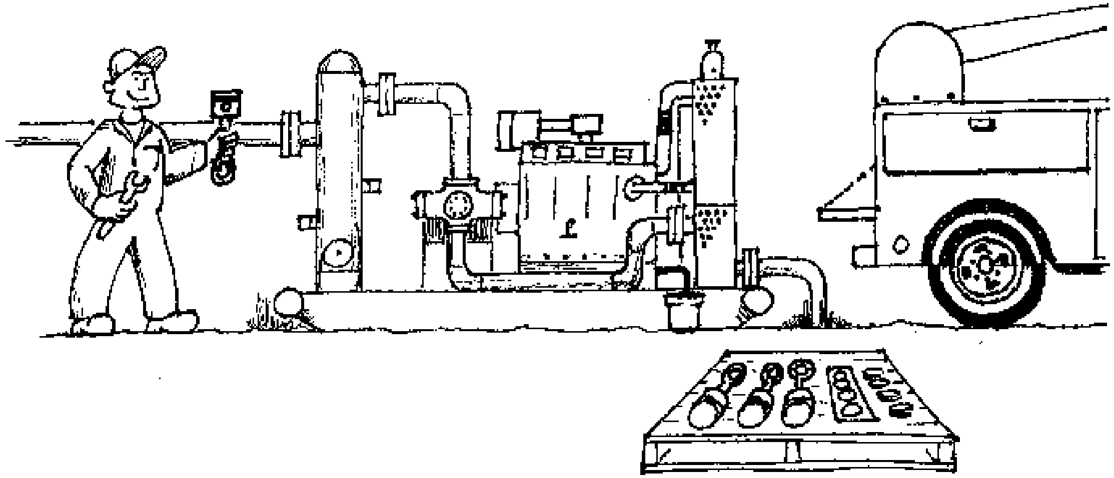
Decision – On-site Overhaul or Replacement?

- <u>On-site Overhaul</u> – rebuild the existing engine with new or refurbished parts. This is described in **Scenarios 1 and 2** of Appendix "B".
- <u>Replacement</u> – exchange the existing engine with a new or refurbished engine & associated accessories. This is described in **Scenarios 3 and 4** of Appendix "B".

On-Site Engine Overhaul

(Engine does not leave site)

- On-site Overhaul – rebuild existing engine with new or refurbished parts. This is described in **Scenarios 1 and 2** of Appendix "B".



On-Site Engine Overhaul – cont'd

(Engine does not leave site)

- Reconstruction costs include:
  - Labor to overhaul engine in place,
  - Parts to replace worn components as required:
    - Pistons, rings & liners
    - Bearings
    - Seals
    - Gaskets
    - Pumps
    - Valve train
  - Subcontractors or machine work.

On-site Engine overhaul – cont'd

Completion of Overhaul and Engine Start-up

Reconstruction Costs Include:

- Labor & crane to re-install accessories and guards removed for access to engine.
- Labor to fill with fluids and test run engine, checking for leaks, vibration, etc. Purchases of routine items such as oil, antifreeze, and plugs are not included
- Check all engine shut down devices, fuel pressure, ignition timing, temperatures and pressures.
- Run engine with compressor loaded.

Engine is removed from site for off-site overhaul or replacement with an exchange engine

1. Decision is made to remove old engine (described as engine “A”)
2. Options for replacement…

   – If engine is repairable, and time is available, have the engine overhauled and reinstalled. This is described in **Scenario 3** of Appendix “B” (engine “A” returns to the package and is reinstalled).

   – If time is limited, return old engine for an exchange engine of same make and model that has been overhauled. This is described in **Scenario 4** of Appendix “B” (exchanged engine is installed on package –often referred to as a “Swing Engine”).

Engine removed from site – cont'd

Worn/Damaged Engine Removal

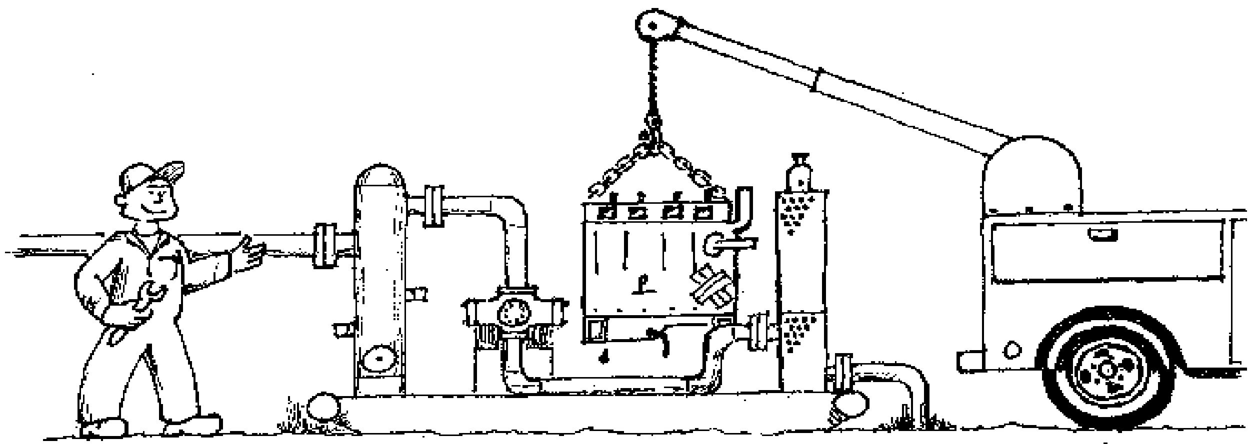
- Reconstruction costs may or may not include Package disassembly (piping, guards, accessories, bolting, electrical) to allow for engine removal.

    - Worn/damaged engine "A" removal costs ARE included if engine "A" is reinstalled (scenario 3 of Appendix "B").

    - Worn/damaged engine "A" removal costs are NOT included if exchange engine is reinstalled (scenario 4 Appendix "B").

Explanation: If engine "A" is not reinstalled, then it is no longer a concern for the Owner and Operator as part of the reconstruction analysis since the analysis is being done on the replacement engine. Therefore the breakout costs for engine "A" are only included if it is re-installed.

Engine removed from site – cont'd
Worn/Damaged Engine Removal

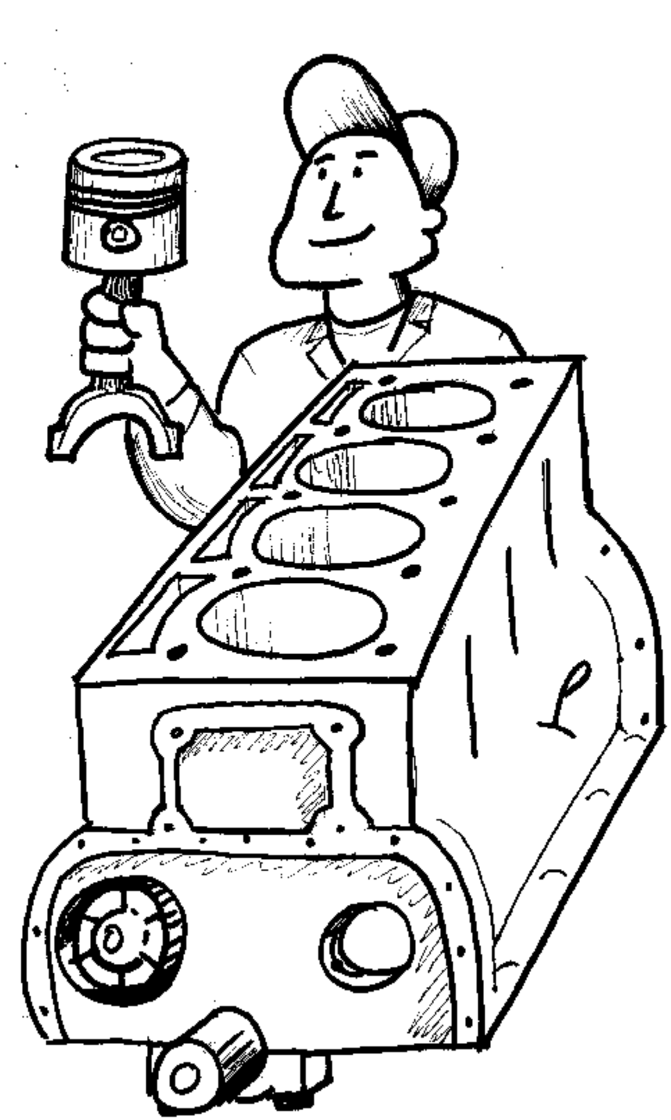


Removal of old engine "A"

Engine removed from site – cont'd

Scenario 3 – Engine "A" Overhauled in Shop for re-installation

- Reconstruction costs to include:
  - Materials
  - Labor
  - Trucking/freight
  - Machining
  - Miscellaneous shop expenses



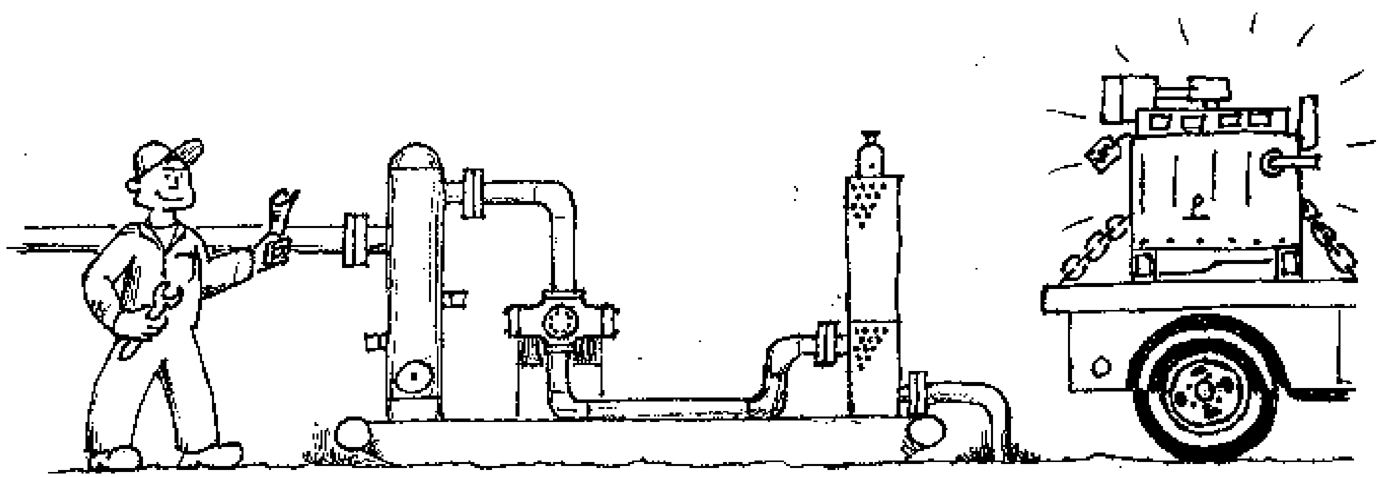
Engine removed from site – Cont'd

Scenario 4 – Rebuilt exchange Engine is Purchased

- Reconstruction costs to include:
  - Price of engine reflective of work done on the exchange engine received such as additional machining or repair
  - Core value associated with the exchange engine is not included, since this represents the purchase of the exchange engine, rather than the overhaul cost.
  - Trucking/freight of the exchange engine (but not of engine "A")

Engine removed from site – cont'd
Reinstall Engine & Accessories

- Reconstruction costs include:
  - Labor to reinstall engine "A" or to install replacement engine,
  - Labor for realignment with compressor,
  - Crane, rigging, permit and transportation costs.
  - Parts and labor associated with Ancillary items if repaired or replaced in conjunction with overhaul



Engine removed from site – cont'd

Completion of Overhaul and Engine Start-up

Reconstruction costs include:

- Labor & crane to re-install accessories and guards removed for access to engine.
- Labor to fill with fluids and test run engine, checking for leaks, vibration, etc. Purchases of routine items such as oil, antifreeze, and plugs are not included
- Check all engine shut down devices, fuel pressure, ignition timing, temperatures and pressures.
- Run engine with compressor loaded.

Summary Matrix for costs to include as part of work performed

	Engine Overhauled on Site		Engine Removed from Site	
	Scenario 1 – Integral Engine	Scenario 2 – Separable Engine	Scenario 3 – Engine A removed, overhauled and re-installed	Scenario 4 – Engine A removed and replacement engine installed
Engine A Removal and freight FROM site	n/a	n/a	Include	Do not include
Engine overhaul cost such as labor, parts and machine work	Include	Include	Include for Engine A	Include costs associated with replacement engine not including core
Crane Trucking of engine TO site	n/a	n/a	Include for Engine A	Include costs associated with replacement engine
Re-install engine after overhaul	n/a	n/a	Include	Include
Start up of engine after overhaul	Include	Include	Include	Include

Appendix "B"

To

GCA Methodology for Calculating Reconstruction of Natural Gas Compressor Packages

Acknowledgment: This information was provided courtesy of Jeff Adams
Revised: October 1, 2009

Guideline on Modification/Reconstruction for
RICE MACT and Stationary ICE NSPS

Modification – Defined in 40CFR60.2 & 60.14 for NSPS, is not a NESHAP concept. Is not triggered when relocating to other locations or rebuilding to original design specifications. Modification is triggered when design specs are changed to increase hp above maximum engine rating[1] (i.e. increased turbocharger), provided potential to emit (PTE) increases. Additionally, the engine has also been modified if the basic design of the engine has been **modified** (i.e. removing an air-to-fuel ratio controller or modifying an engine from a lean-burn to a rich-burn), so that the emissions of a pollutant increase[2].

Reconstruction – Defined in 40CFR60.15 for NSPS and 40CFR63.2 for NESHAP and is defined as the fixed capital cost[3] of the new components exceeding 50 percent of the fixed capital cost that would be required to construct a comparable new source (see End Note for a discussion on "source/facility"). Reconstruction is a cost based, event driven concept that is totally independent from modification criteria. An event consists of all of the applicable cost performed at a single time, unless the related changes are phased due to cost or compliance purposes. In the simplest terms, the fixed capital cost of the new components (the numerator) includes the engine cost of all new parts, labor, transportation, and other associated cost. The fixed capital cost that would be required to construct a comparable new source (the denominator) include all parts, labor, transportation, engineering and other associated cost to install and get a new similar unit operable[4]. The following scenarios illustrate the details and complexities of cost to be included in the numerator and denominator in the reconstruction calculation for engines.

1. An existing engine is rebuilt on the site.

Item Description	**Numerator**	**Denominator**
Overhaul Cost – See Endnotes for further definition of descriptions in tables[5]	X	
New engine cost [6, 7]		X
Site installation cost		X
Start up cost	X	X

2. An existing integral compressor engine is rebuilt on site.

Item Description	**Numerator**	**Denominator**
Overhaul Cost	X	
New engine cost		X
New driven equipment cost[8]		X
Site installation cost		X
Start up cost	X	X

[1] Higher rating of the original manufacture maximum power rating or pre-June 12, 2006 modification power rating.
[2] If pollution controls (i.e. catalyst) are added at the same time so that the emissions do not increase, no modification has been made.
[3] Fixed capital cost means the capital needed to provide all the depreciable components.
[4] A new similar unit in the denominator does not have to be an exact replacement, but must perform similar work (i.e. for a compressor the same combination of throughput volume & compression ratio increase, which is essentially horsepower). Ancillary systems (i.e. fuel, lubrication, engine cooling, ignition, engine control, foundation, buildings and other systems required for the engine to run) are included as if the engine was installed at a green-field site.
[5] Does not include cost of routine maintenance items such as changing oil, coolant, belts, spark plugs & wires, etc., but routine maintenance does not include scheduled overhauls.
[6] Any system (i.e. fuel, starting air, lubrication) that supports more than the unit being considered (i.e. the driven end, other engines, or other processes/activities) should be prorated by number of units supported.
[7] The cost of emission control equipment (except where it is a part of the process equipment, such as with lean burn engines and air-fuel ratio controllers) is not included in the denominator.
[8] Integral compressors are built with the compressor rods connected to the engine crankshaft. There is no reasonable way to separate repair cost of the engine and compressor or to replace just the engine. A similar new unit must be composed of both the engine and the compressor.

3. An existing engine is removed from the site, sent to a shop to be rebuilt and reinstalled at the same location.

Item Description	Numerator	Denominator
Site dismantlement and removal cost – including labor, engineering, transportation, and other associated cost.	X	
Overhaul Cost	X	
New engine cost		X
Site installation cost	X	X
Start up cost	X	X

4. An existing engine is sent to a shop to be rebuilt and relocated to another site, purchased as refurbished engine from a used equipment vendor[9], or removed and exchanged from a pool of already refurbished engines[10]. In all of these cases, an existing engine has associated overhaul cost and is installed at a different location[11].

Item Description	Numerator	Denominator
Book value of existing engine.		
Previous site dismantlement and removal cost		
Overhaul Cost[12]	X	
New engine cost		X
Site installation cost	X	X
Start up cost	X	X

---

[9] The price of a refurbished engine is comprised of two components, the book value of the existing engine and the overhaul cost. Ensure that the overhaul cost is specifically included as a separate line item by the equipment vendor.

[10] The pool of refurbished engines can be an internally or externally owned pool of replacement engines that are ready to install. If the pool of engines are externally owned, the existing engine maybe exchanged as a core (in lieu of the book value paid in the purchase of a refurbished engine, see footnote 6) and the overhaul cost is the total cost of the exchange. In the case of internally owned refurbished engines, the book value is typically ignored and the overhaul cost is associated with the installed engine.

[11] The concept of relocated equipment maintaining the regulatory status is clarified in the NSPS at 40CFR60.14(e)(6) in discussing reconstruction and in the NESHAPs at 40CFR63.2 in the definition of construction. Backup for the relocation provisions in the NESHAP construction definition can be found in the February 2002 Background Information Document (BID, see page 12-14) to the final General Provisions finalized on April 5, 2002 and the February 1994 BID to the final NESHAP, General Provisions finalized on March 16, 1994, (see page 2-61&62)

[12] Cost of overhaul/repair for an engine must be included regardless of whether it was paid for directly by BP or indirectly to a vendor as part of the exchange or purchase price. The vendor or previous owner should be asked to separate the overhaul cost from book value or purchase price for compliance purposes.

End Notes: The “affected source” used in “reconstruction” in the RICE MACT is clearly defined as the RICE (engine) in NESHAP, Subpart ZZZZ. The “existing facility”/”affected facility” used in “reconstruction” in the NSPS General Provisions, Subpart A is not as clearly specified in NSPS, Subpart JJJJ and leaves doubt on whether the driven source (i.e. compressor and associated piping) should be included in the reconstruction calculation. Since Subpart JJJJ regulates the exhaust emissions from engines, existing/affected facility must also be the engine alone.

Affected facility means, with reference to a stationary source, any apparatus to which a standard is applicable.

Existing facility means, with reference to a stationary source, any apparatus of the type for which a standard is promulgated in this part, and the construction or modification of which was commenced before the date of proposal of that standard; or any apparatus which could be altered in such a way as to be of that type.

Stationary source means any building, structure, facility, or installation which emits or may emit any air pollutant.

Definition of Terms Used in Tables

Overhaul Cost – Cost of replacement (worn or upgraded components) and repair (fixing damaged or broken parts) of parts including associated installation labor, part repair or custom manufacture, etc.

New engine cost – including fuel, lubrication, engine cooling, ignition, engine control, foundation, buildings and other systems required for the engine to run.

Site installation cost – including labor, engineering, transportation, and other associated cost.

Start up cost – including operability testing, debugging, setting adjustment, emission testing, etc.

Appendix "C"

To

GCA Methodology for Calculating Reconstruction of Natural Gas Compressor Packages

Example Calculations: These examples are for instructive purposes only and are not intended to represent an actual reconstruction evaluation.

GCA Engine Reconstruction – Example Calculation

10/20/2009

Scenario #1: Engine overhauled on site

Cost Calculation:	Engine Overhaul Cost
Existing versus New	Comparable Entirely New Facility

Where:

Numerator = engine repair, trucking, crane & startup labor costs included.

Denominator = New Engine + Ancillary + Site Installation & Startup

Actual Cost Calculation: Overhaul versus New	$18,600	/	$54,372	=	34%

Engine is below reconstruction criteria

Engine & Package Information:

Horsepower Rating	135	horsepower (used for generic factors)
at rated speed	1200	RPM
Unit #1234 - ACME Model 135		
High speed separable package		
Type of Overhaul	Engine removed and re-installed	
Date of Overhaul	1/1/2008	(used for PPI adjustment)

Existing Engine Overhaul Costs (Numerator)	Cost
Engine Repair parts & labor	$16,500
Trucking & Lifting Services	$1,300
Commissioning & Startup Labor	$800
Other	$0
Total Numerator	$18,600

Comparable New Facility (Denominator)

Package Details: 135 HP Natural Gas fired RICE

Component	Method Used	Cost
New OEM Engine Cost:	Quote	$25,000
Ancillary Items (use either method 1 or 2) 1: Generic Factors --> $22,815 2: Model Specific ---> $24,013	Model/Case Specific Estimate	$24,013
Installation, start-up and commissioning (use either method 1 or 2) 1: Generic Factors --> $5,805 2: Case Specific ------> $6,750	Model/Case Specific Estimate	$6,750
Sub-total Denominator prior to PPI adjustment		$55,763
PPI Ajustment		98%
Total Denominator		$54,372

Model Specific Ancillary Item Estimate Worksheet (use 2009 dollars)			
pro-rated for engine related portion only	Estimated New Cost	% Engine related	Engine Ancilliary Adder Costs (New x CGA Pro-rated %)
Engine Ancilliary System Adders:			
Skid	$8,000	25%	$2,000
Engine Cooler	$10,000	40%	$4,000
Control Panel & Wiring/Tubing	$3,500	7.5%	$263
Fuel, Starter, Exhaust & Oil Systems	$14,000	100%	$14,000
Packaging Labor	$15,000	25%	$3,750
Total Model specific Ancillary item estimate			**$24,013**

Case Specific Installation, start-up and commissioning Estimate Worksheet (use 2009 dollars)			
New Package Installation Adders:	Estimated New Cost	% Engine related	Engine Installation, start-up and commissioning Costs
Trucking			$1,500
Cranes			$1,000
Hookup Labor & Parts			$500
Commissioning Labor			$500
Fuel/Start gas Reconnection			$250
Emissions Testing			$3,000
Total case specific Installation, start-up and commissioning estimate			**$6,750**

GCA Engine Reconstruction – Example Calculation

3/1/2009

Scenario # 3 - Engine removed, overhauled and re-installed

Cost Calculation: **Existing versus New**	Engine Overhaul Cost Comparable Entirely New Facility

Where:

Numerator = engine repair, trucking, crane & startup labor costs included.

Denominator = New Engine + Ancillary + Site Installation & Startup

Actual Cost Calculation: Overhaul versus New	$55,290	/	$82,600	=	67%

Engine may be reconstructed, submit applicability determination

Engine & Package Information:

Horspower Rating 200 horsepower (used for generic factors)

at rated speed 1200 RPM

Engine is an ACME model 200 which is no longer manufactured. For a new facility a comparable engine (200 hp at 1200 RPM) is an ACME model 250 which is a current production engine

Type of Overhaul: Engine removed and re-installed

Date of Overhaul: 2/1/2009 (used for PPI adjustment)

Existing Engine Overhaul Costs (Numerator)	Cost
Engine Repair parts & labor	$51,200
Trucking & Lifting Services	$1,390
Labor and mileage to remove and re-install engine	$2,700
Other	$0
Total Numerator	$55,290

Comparable New Facility (Denominator)

Package Details: 135 HP Natural Gas fired RICE

Component		Method Used	Cost
New OEM Engine Cost:		Quote G3406 TA	$55,000
Ancillary Items (use either method 1 or 2)			
1: Generic Factors -->	$23,400	Generic Factors	$23,400
2: Model Specific --->	$0		
Installation, start-up and commissioning (use either method 1 or 2)			
1: Generic Factors -->	$4,200	Generic Factors	$4,200
2: Case Specific ------>	$0		
Sub-total Denominator prior to PPI adjustment			$82,600
PPI Ajustment			100%
Total Denominator			$82,600

GCA Engine Reconstruction – Example Calculation

10/20/2009

Scenario #4: Engine removed and replacement engine installed

Cost Calculation:	Engine Overhaul Cost
Existing versus New	Comparable Entirely New Facility

Where:

Numerator = engine repair, trucking, crane & startup labor costs included.

Denominator = New Engine + Ancillary + Site Installation & Startup

Actual Cost Calculation: Overhaul versus New	$64,800	/	$141,580	=	46%

Engine is below reconstruction criteria

Engine & Package Information:

Horsepower Rating	400	horsepower (used for generic factors)
at rated speed	1800	RPM
ACME Model 400		
high speed separable package		
Type of Overhaul	Engine replacement	
Date of Overhaul	11/20/2008	(used for PPI adjustment)

Existing Engine Overhaul Costs (Numerator)	Cost
Engine Repair parts & labor	$59,100
Trucking & Lifting Services	$3,000
Commissioning & Startup Labor	$1,700
Contract labor to rework engine mounts	$1,000
Total Numerator	$64,800

Comparable New Facility (Denominator)

Package Details: 125 HP Natural Gas fired RICE

Component	Method Used	Cost
New OEM Engine Cost:	Quote	$90,000
Ancillary Items (use either method 1 or 2) 1: Generic Factors --> $46,800 2: Model Specific ---> $0	Generic Factors	$46,800
Installation, start-up and commissioning (use either method 1 or 2) 1: Generic Factors --> $8,400 2: Case Specific ------> $0	Generic Factors	$8,400
Sub-total Denominator prior to PPI adjustment		$145,200
PPI Ajustment		98%
Total Denominator		$141,580

Appendix "D"

to the

GCA Methodology for Calculating Reconstruction of Natural Gas Compressor Packages

Typical Installation, start-up and commissioning costs for a NEW natural gas compressor package driven by a RICE

		Horsepower Class				
Cost Component	**% Engine**	**<100**	**100-199**	**200-499**	**500-999**	**1000-1750**
Trucking	25%	$ 150	$ 150	$ 150	$ 1,642	$ 3,042
Cranes	25%	$ -	$ 375	$ 750	$ 1,333	$ 1,667
Pad / Foundation	25%	$ 125	$ 188	$ 250	$ 892	$ 1,833
Fuel/Start Gas piping and meter	100%	$ 500	$ 750	$ 1,000	$ 2,267	$ 2,267
Labor to install Cooler	40%	$ 60	$ 99	$ 106	$ 191	$ 196
Labor & vehicle to commission engine	100%	$ 215	$ 215	$ 288	$ 430	$ 503
Engineering	10%	$ 50	$ 100	$ 200	$ 300	$ 500
Emissions testing	100%	$ 2,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000
Environmental Permitting	100%	$ 500	$ 500	$ 500	$ 500	$ 500
Total Cost		$ 3,600	$ 6,377	$ 7,244	$ 11,554	$ 14,507
Average horsepower for class		75	150	350	750	1,350
Dollars per horsepower ($/hp)		**$ 48**	**$ 43**	**$ 21**	**$ 15**	**$ 11**

Note: The preceding does not inlcude any cost associated with:

- Monitoring or SCADA
- Buildings or sheds
- Oil Storage tanks
- Installation or commissioning of driven equipment