# Preliminary Cost Information for Nuclear Components

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# Nuclear versus Non-nuclear component costs for mechanical parts

- *Some data has been collected from cost estimators at INL.*
- *Nuclear-grade steels for fission reactors typically cost up to 10x more than typical steels used in industry.*
  - *Some reasons for that high cost are alloying of nuclear steel over carbon steel, the Certified Material Test Reports (CMTRs), and quality assurance.*
- *A CMTR is documentation that follows the material from a metal billet or heat at the foundry to finished component. A CMTR includes chemical analysis of constituent materials and impurities, and physical property tests.*
- *Nuclear grade mechanical components (N-stamp), such as valves, tend to cost at least 2x and up to 3x more than commercial mechanical components.*

# Nuclear and Non-nuclear component costs for mechanical parts

- ***Reasons for cost differences of mechanical components in nuclear and non-nuclear (commercial) applications, such as flow systems, are:***
  - ***Care in alloy composition, the CMTRs, weld maps, welder certifications, non-destructive evaluation, inspections by an ASME certified inspector, quality assurance, and documentation.***
  - ***The customer performs independent tests of the materials, must compare the results to the CMTRs and evaluate the differences.***
- ***Mechanical component N stamp remains a requirement in the fission industry.***

# Nuclear and Non-nuclear costs for Electrical components

- *There are several grades of quality in electrical power distribution components. These are:*
  - *Residential*
  - *Commercial*
  - *Industrial*
- *Costs increase as the robustness of the component increases*
- *Electrical components receive a Certificate of Compliance. This tends to be less paperwork and cost than the CMTRs +NDE+inspections for mechanical components.*
- *Costs of IEEE Class 1E electrical equipment for use in fission plants in general do not increase as much as that of mechanical components, less than 2x added cost for robust electrical equipment that has been proven to meet nuclear standards.*

# Trends for Electrical components

- ***In the last 15-20 years there has been a growing trend of electrical component vendors shying away from nuclear quality assurance levels. Nuclear QA and pedigree are high cost and the market is small.***
- ***Electrical vendors have been saying "this is our industrial grade component, take it or leave it." Fission plants have begun using industrial electrical components for replacement parts as they exhaust their stores of spare parts.***

# Some component costs

- ***Costs from various trade articles on replacement activities at LWRs give these approximate fabrication costs:***
  - ***Steam generators, $25-30M (1,000 tons, 75 ft tall, 25 ft dia)***
  - ***Condenser tube bundle module, $6M (500 tons x 12 modules, 56 ft long x 30 ft high x 35 ft wide modules)***

- ***The Lang Factor, a multiplier on fabrication cost to estimate the component's transport and installation cost, can be used. Often a Lang Factor of 4.8 is used in initial estimates.***
- ***INL cost estimators typically use the Richardson process plant construction cost estimation data (www.costdataonline.com) and sometimes use the RS Means construction cost estimation data (www.rsmeans.com), as well as published cost studies.***

# Some plant cost estimates

- ***An INL study on HTGR direct costs was finished in 2011. For a 950 C reactor outlet temperature, 600 MWt plant, the cost data in 2009 $ are:***

| System | FOAK Cost ($M) | NOAK Cost ($M) |
|---|---|---|
| Reactor building | 237.8 | 126.3 |
| Reactor Vessel | 145.4 | 123.3 |
| Reactor metal internals | 90.8 | 64.2 |
| Reactor graphite | 31.8 | 25.4 |
| Refueling system | 92.2 | 69 |
| Reactor cavity cooling | 28.9 | 22.1 |
| Heat rejection system | 42 | 40 |
| IHX | 54.7 | 46.5 |
| Brayton conv. vessel | 109.2 | 92.6 |
| Brayton power system | 372.5 | 144 |
| Rankine power system | 224.1 | 166.9 |
| Total plant-Brayton | 1,648 | 1013.8 |
| Total plant-Rankine | 1,325 | 926.6 |

- ***Accuracy range is -30% to +50%.***

# Conclusions

- ***The fission industry is having difficulty in obtaining electrical parts that meet IEEE 1E standards, they've begun using the highest industrial grade electrical components. There has not been any deviation on mechanical parts. These parts are still required to meet ASME rules.***
- ***Cost data are not easily found, only overall costs tend to be given in the literature, leading to difficulty in interpreting if costs are just fabrication or include installation costs. For a coarse level of design detail, cost estimates have large error bounds.***

## references


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