International Journal of Research in Engineering and Innovation Vol-10, Issue-3 (2026), 95-99

International Journal of Research in Engineering and Innovation (IJREI)

Journal home page: https://ijrei.com/

ISSN: 2456-6934

RESEARCH PAPER

# Performance enhancement of VCR using a water condenser using HFO blended Refrigerants with nano fluids in the secondary circuit of the evaporator

**Radhey Shyam Mishra**

*Department of Mechanical, Production, Industrial and Automobile Engineering, Delhi Technological University, Delhi, India*

**Article Information**

Received: 21 February 2026
Revised: 29 April 2026
Accepted: 10 June 2026
Available online: 12 June 2026

**Keywords:**

Low GWP refrigerants
Thermal performance
VCR systems using Nano Materials

**Abstract**

This paper's primary goal is to reduce the direct environmental impact of cooling systems by limiting their energy usage, which can be done by presenting the most recent advancements in this technology. It offers appropriate substitutes for the existing refrigerants to decrease the cooling systems' direct environmental impact. The passive methods that can also be utilized to lower the cooling load or, in certain situations and can replace the mechanical systems. Both directly and indirectly, vapour compression refrigeration systems have a major impact on global warming. Furthermore, the vapour compression cycle cannot be replaced in the foreseeable future by any superior technology. Therefore, it is essential to reduce the vapour compression refrigeration cycle's negative environmental effects. Using nano fluids in the secondary circuit of evaporator and HFO blended refrigerants ( i.e. R450A, R515a, R513a) and it was found that the $TiO_2$ nano mixed glycol-based fluid is mainly utilized in the evaporator's secondary circuit, giving lowest thermal performances than copper oxide mixed glycol based fluid flow in the secondary circuit of the evaporator and maximum enhancement was 20.2% using R515a and copper oxide as nano material in glycol water solution in the evaporator secondary circuit and 7.79% using $TiO_2$. 

## 1. Introduction

Refrigeration is a technology that rejects heat from the environment at higher temperatures while absorbing heat at lower temperatures. The four main parts of a vapour compression refrigeration system are the compressor, expansion valve, condenser, and evaporator. In many applications, such as large hotels, food storage facilities, and food processing plants, food items are stored in separate compartments at different temperatures. A multi-evaporator vapor compression refrigeration system is therefore required. Systems using vapour compression technology use a significant amount of electricity; this issue can be resolved by enhancing system performance. The following actions can enhance the performance of vapour compression refrigeration systems. The vapour compression Refrigeration (VCR) systems with a higher coefficient of performance (COP) use less energy per tonne of refrigeration and have smaller carbon footprints. This kind of system is beneficial to society and the environment because air conditioning and refrigeration systems that run on VCR systems use a significant amount of energy (about 30%) worldwide.

COP, or the ratio of the refrigeration effect to the net work input provided to the system, is used to assess a refrigerator's performance. Either boosting the refrigeration effect or lowering the work input provided to the system will increase the COP of a vapor compression refrigeration system. (ii) The throttling process in a VCR is a well-known irreversible expansion process. One of the primary causes of energy loss in cycle performance is the expansion process, which causes a portion of the refrigerant to flash to vapour in the evaporator, increasing the evaporator's size and decreasing

*Corresponding author: R. S. Mishra*
*Email Address: rsmishra@dtu.ac.in*
https://doi.org/10.36037/IJREI.2026.10302

its cooling capacity. By boosting superheating and subcooling or recovering expansion losses, the refrigeration cycle COP can be increased. There are other ways to increase sub-cooling and super-heating, such as suction line heat exchangers, mechanical sub-cooling, and thermo-electric sub-cooling. The best sub-cooling or super-heating technique relies on the application and is closely tied to the characteristics of the refrigerant [2]. The best way to address the environmental problems associated with the vapour compression refrigeration cycle is to use natural refrigerants. Since carbon dioxide and water are the safest and most effective natural refrigerants, they are the most promising. Water is an extremely safe and effective refrigerant that might address the majority of refrigerant-related environmental issues. To address the technical issues with using water as a refrigerant, more research is necessary. Using direct expansion and condensing techniques, as well as encouraging industrial cooperation to lower the cost of water compressors, are the suggested solutions for using water as a refrigerant. The performance of the refrigeration cycle could be enhanced by using a cascade refrigeration cycle and cycle modifications such an expander or two-phase ejector. However, they rely heavily on the thermos-physical characteristics of the refrigerant, therefore careful investigation is necessary to select the best method. With an emphasis on water, this study offers a summary of the most recent advancements in vapour compression systems, including methods that could be applied to lower energy usage and an overview of refrigerants and natural refrigerants. The environmental impact of cooling systems could be reduced with more study on literature review on VCRS. As a low-GWP (Global Warming Potential) non-flammable replacement for R-134a [3].

## 2. Eco-friendly Refrigerants

The primary risk of greenhouse gases is an increase in global warming, which can be avoided by stopping refrigerants from depleting the ozone layer. Global warming potential (GWP) levels have a significant influence on how directly refrigerants affect the environment. As a result, reduced GWP values have positive effects on the environment. Refrigerants derived from HFCs are expected to contribute roughly 2% of all greenhouse gasses. Furthermore, in the next thirty years, refrigerant emissions could increase by up to ten times if they are not controlled. Until the end of the century, HFCs are expected to contribute between 0.28 and 0.52 K to global warming. The global agreement to reduce HFC emissions has accelerated as a result of this circumstance. The Kigali Amendment was the most significant move in the previous ten years in this regard. There, it was said that affluent nations will gradually cut back on HFCs by 2019 and that poorer nations would stop using them between 2024 and 2028. The European F-Gas Regulation (Regulation (EU) No 517, 2014) states that starting on January 1, 2022, small capacity refrigerators and freezers with hermetic compressors may only utilize refrigerants with GWP values less than 150 [4]. Approximately one-third of the HFC used worldwide is used in commercial refrigeration. R404A is a common refrigerant used in commercial refrigeration systems, particularly in supermarkets. Using R404A with high-GWP in refrigeration systems increases negative environmental effects both directly and indirectly. HC derivatives are classified as safety group A3 low-GWP refrigerants because of their extreme flammability and limited charging capacity. In a similar vein, the GWP values of HFC derivative refrigerants are high. Although they are categorized as mildly flammable, HFO-based refrigerants, commonly known as fourth generation gases, have a low GWP value. Research into non-flammable, low-GWP refrigeration mixes that also provide improved energy performance has increased. Refrigerant combinations of the HFC/HFO type are hence viable substitutes for upcoming refrigeration systems. R32 or R134a are utilized as HFC and R1234yf and R1234ze as HFO in HFC/HFO mix. The percentage of refrigerants in the mixture determines GWP values and flammability classification. Studies on A1 safety class HFC/HFO mixes and HFCs mixtures claim that because their GWP values are higher than those of lower flammability mixtures, those mixtures do not show promise in the long run. The percentage of refrigerants in the mixture determines GWP values and flammability classification. According to research on A1 safety class HFC/HFO and HFC mixes, these mixtures don't show promise over the long run because their GWP values are higher than those of mixtures with reduced flammability.

## 3. Hydrofluoroolefin (HFO) blended HFC refrigerants

HFC refrigerants mixed with hydrofluoroolefin (HFO) in commercial refrigeration systems operating at low and medium temperatures, HFO mixed HFC refrigerants were frequently employed in place of high GWP and zero ODP refrigerants. The composition of HFO blended HFC refrigerants and environmental factors related to ozone depletion and global warming. For home refrigeration, a comparison between the new combination R513A (made up of R134a/R1234yf) and R134a was done [5]. It was shown that R513A used 3.5% less energy in a 24-hour period than R134a. As a novel substitute for R134a refrigerant in automobile air conditioning systems, evaluated the HFC/HFO mixture (R1234yf/R134a with 89%/11% by mass). The COP of the R1234yf/R134a mixture was discovered to be 4–9% lower than that of R134a in the cooling mode [6] .

The used R32/R1234yf mixture (20% and 80% by mass) as the working fluid in a gas injection heat pump system and heating performance was improved from 16 to 20% compared to the situation without gas injection. The system with the mixture under consideration might function at an evaporation temperature of −20 °C. A blend of R32/R290 (68%/32% by mass) was discovered by Tian et al. (2015) to replace R410A in home air conditioners. According to the trial results, the R32/R290 mixture increased cooling and heating capacities by 14% and 23.7%, respectively, while reducing the amount of refrigerant charge by 30% [7]. For warm temperature locations, an experimental comparison of R454C and R454B as substitutes for R404A. The findings showed that, in comparison to R404A, the cooling capacity was marginally lower and the COP was 10–15% greater. Three low-GWP refrigerants and R454C were compared with R404A. It was stated that, in comparison to R404A, both the power consumption and the ideal amount of refrigerant charge were reduced with R454C. Similarly, R454B and R454C have lower volumetric cooling capacity values than R404A. Studies comparing R404A with low-GWP refrigerants can be found in the literature. As alternatives to R404A, for instance, R448A and R454BA, R449A and R452A, the alternative refrigerants are R32/R1234yf combinations. The GWP values are directly impacted by this discrepancy, and they can satisfy different environmental limitation criteria. Therefore, devices that require a GWP of less than 150 can use R454C (GWP=146). An HFC produced near azeotropic combination is the refrigerant R404A. The test bench's expansion valve and compressor are made for R404A. Directly operating the system to charge a different refrigerant in place of R404A refrigerant is one of the study's objectives. R454C, the alternate refrigerant under consideration, can be used in this situation without requiring any structural changes to the system [8].

### *3.1 Use of Nano refrigerants*

Natural refrigerants, such as CFCs, HCFCs, HFCs, HCs, and their mixtures, have been used for many years in a variety of applications. It has been discovered that a number of these refrigerants are quite harmful to the environment, weakening the ozone layer and raising the possibility of global warming. Since then, scientists have been trying to create new refrigerants that will improve the efficiency of current systems while also resolving the aforementioned environmental problems. One of these more recent developments in refrigeration systems is the use of nanofluids. The fundamental components of a nanofluid are nanoparticles, which can only be measured at the nanoscale. Because of their enhanced thermophysical characteristics, nano refrigerants—a colloidal suspension of nanoparticles in the base refrigerant—have steadily emerged as one of the most promising and effective heat transfer fluids in a variety of thermal engineering applications. The reliability and functionality of a home refrigerator with nanoparticles in its working fluid were investigated experimentally. Few investigators discovered that using combinations of mineral oil and TiO2 nanoparticles instead of polyol-ester (POE) oil performed better than HFC134a and required 26.0% less energy with 0.1% mass fraction TiO2 nanoparticles [9] .The ecofriendly hydrocarbon used R600a with ZnO and $SiO_2$ hybrid nano lubricants to combine two distinct nanoparticles, such as ZnO and $SiO_2$, in a VCR system at variable concentrations[10]. The experimentally the efficiency of R134a-$ZrO_2$ nano refrigerants at a concentration of 0.2 g/l in a domestic refrigerator without changing the constituent parts, and discovered more than 40% improvement in the system's performance coefficient, rise in cooling capacity, and decrease in compressor electrical power consumption using hybrid nano lubricants. Studies were carried out to assess the refrigerator's performance following the charging of 140 g of R134a and 0.2 g/L of $ZrO_2$ nanoparticles with a particle size of 1–10 nm. [11]. A number of nanoparticles, including TiO2, Al2O3, CuO, $SiO_2$, ZnO, $ZrO_2$, ZnO/$SiO_2$, and diamond, affected the suction and discharge pressures, refrigeration effect, power consumption, and COP) of common refrigerants. Nanofluid is a revolutionary fluid with special qualities that is used in many different industrial heat transfer operations. Using four combination nanofluid samples at four different volume concentrations [12] Venkataiah S. and Gudimalla Sthithapragna [2022]. The greatest increase in thermal conductivity for CuO-Jatropha oil nanofluids was caused by the two-step method of dispersing nanoparticles into Jatropha oil. CuO-Jatropha oil nanofluids' thermal conductivity is disrupted by three factors: temperature, volume concentration, and volume concentrations of the mixture of nanoparticles. The results showed that at temperatures between 298 and 323 K, nanoparticles had an impact on the increase in thermal conductivity and viscosity. The productivity of refrigeration systems has increased dramatically with the development of nano refrigerants. The thermal and heat transport characteristics of nano refrigerants are excellent. Using single walled carbon nanotubes (SWCNTs) nanoparticles, thermal conductivity, viscosity, COP, and energy savings were evaluated theoretically for volume concentrations of 0.5, 1, 2, and 3 vol% in HFC-134a and HFC-152a refrigerants [13]. The significant heat conductivity of nanoparticles was the reason for the increase in energy efficiency (COP) for both nano refrigerants. R152a-based nano refrigerants have shown the highest COP values when compared to R134a-based nano refrigerants. The R152a-based nano refrigerant showed a maximum increase in COP of 1.43% when compared to base refrigerant R152a [14]. A thermal model was created to assess the energy-exergy performance of VCR systems using HFC-134a in the primary circuit and an Al2O3 water-based nanofluid in the secondary circuit. This model takes into consideration the size of the nanoparticles, compressor speed, and other geometric characteristics of the secondary fluid while forecasting the operating pressure, temperature, power consumption, and overall system performance [15]. The effects of temperature and volume on the viscosity of R123-TiO2 nano refrigerant at temperatures ranging from 5°C to 20°C was examined with a maximum volume concentration of 2% of nanoparticles [16]. According to the model's results, the system energy performance can be improved by about 17–20%. The effects of pressure drop with increased viscosity have also been studied. The conductivity ratio between pure and nano refrigerant increases with the concentration of nanoparticles in the host refrigerant.

Conversely, CuO nanoparticle-based nano refrigerants have a higher conductivity ratio than other nanoparticles and are roughly twice as high as base refrigerant at 5 vol% concentration, whereas eco-friendly HFC-134a with CuO nanoparticles has a maximum effectiveness factor of about 3.2 at 5 vol%. When compared to other nanoparticles combined in brine water, the copper mixed nano refrigerant has the highest convective heat transfer coefficient ratio in the evaporator's secondary circuit. As the volume percentage (vol%) rises, so does the efficiency factor [17].

Many researches have examined the thermal performance of low global warming potential (GWP) refrigerants, like HFCs and HFOs, in the primary and secondary circuits of the evaporator. In comparison to base refrigerant R134a, R407c, and R404A, thermal conductivity, dynamic viscosity, and density of nano-refrigerant (different nanoparticles, such as

CuO, $Al_2O_3$, and $TiO_2$) increased by roughly 15%, 20%, and 12%, respectively. R. S. Mishra [2024] examined the effects of adding different nanoparticles combined with eco-friendly refrigerant and their effects on the coefficient of performance (C.O.P.). The new HFC refrigerants are being replaced with hydrofluoroolefins (HFOs). These refrigerants may contribute to global warming but have a far shorter atmospheric lifetime than HFCs.

*3.2 Future Refrigerant*

One of the most promising natural refrigerants is water. Nevertheless, a number of obstacles are preventing the widespread use of water in the refrigeration sector. The following points can be used to summarize these difficulties: The extremely large specific volume of water vapour at low temperatures necessitates a high volumetric flow rate. The comparatively high-pressure ratio is required for the system to function within the typical cooling applications' evaporation and condensation temperatures. The high compressor discharge temperature is brought on by the high compression ratio. The use of composite material axial compressors, the integration of the cycle with a two-phase ejector, the use of direct evaporation and condensation heat exchangers, and the application of the cascade refrigeration cycle are some promising research areas that could make water more appealing as a refrigerant. Additionally, the R-718 cycle becomes more efficient and a viable alternative to the refrigerants now in use by lowering the temperature lift between the cycle's high-pressure and low-pressure sides. Water is still one of the greatest solutions and may provide environmentally friendly cooling, despite the numerous drawbacks of utilizing it as a refrigerant in cooling applications. It is advised that researchers hunt for solutions that could lessen the impact of the technological difficulties related to using water as a refrigerant because water is an environmentally favourable option. Producing more affordable multi-stage compressors and looking into new compressor choices that can manage high-volume flow rates and compression ratios could help address the technical issues related to water. Additionally, finding materials for compressor blades that can tolerate high temperatures and developing novel methods to reduce the cycle temperature could help to hold these issues.

## 4. Results and Discussion

Following input parameters have been taken for computing the thermodynamic first law performances of vapour compression refrigeration system shown in the table-1.

Table 2 shows the evaluation of thermal design performance parameters of VCR systems using three HFO blends refrigerant (R-515A) in the primary circuit and glycol-based CuO nanofluid in the secondary fluid circuit of the evaporator. It has been observed that $TiO_2$ nano mixed glycol-based fluid is mainly utilized in the evaporator's secondary circuit, giving the lowest thermal performance than copper oxide mixed glycol-based fluid flow in the secondary circuit of the evaporator. Similarly, the first law energy performance in terms of COP using copper oxide is better than $Al_2O_3$. The performance improvement using copper oxide is maximum (up to 20.175%) and lowest (8.255%) using $TiO_2$. However, using $Al_2O_3$, the percentage improvement was 14.83%, which is higher than using $TiO_2$ mixed glycol-based fluid. Similarly, the COP improvement by using R513A and copper oxide mixed glycol-based fluid is 14.0%, and by using $Al_2O_3$ mixed glycol-based fluid, and 13.385% and 13.763 by using TiO2 mixed glycol-based fluid. Similarly, the enhancement in the energy efficiency (COP) by using copper oxide mixed with glycol-based fluid is 8.255and the lowest (7.787%) by using glycol-based $TiO_2$ nano fluid in the secondary fluid circuit of the evaporator.

*Table 1: Process parameters for VCR system*

| S. No | Parameter | Value |
|---|---|---|
| 1 | Length of evaporator tube | 11.0m |
| 2 | Length of condenser tube | 16.6m |
| 3 | Mass flow rate of brine (Actually varying from 0.06 to 0.12kg/sec) | 0.007 kg/sec |
| 4 | Mass flow rate of water (Actually varying from 0.06 to 0.12kg/sec) | 0.008 kg/sec |
| 5 | Inlet temperature of glycol-based fluid | 300K |
| 6 | Inlet temperature of water -based fluid | 300K |

*Table 2: First law performance and enhancement using nano fluids in VCR systems*

| HFO Blends | R515A | R513A | R450A |
|---|---|---|---|
| COP Without Nano | 2.98 | 2.967 | 2.915 |
| COP with Nano using CuO | 3.579 | 3.395 | 3.388 |
| % enhancement in COP using CuO | 20.175 | 14.0 | 13.763 |
| % enhancement in COP using $Al_2O_3$ | 14.83 | 13.385 | 11.169 |
| % enhancement in COP using $TiO_2$ | 8.255 | 8.169 | 7.787 |

## 5. Conclusions and Recommendations

The various studies on nano-based refrigerants to enhance heat transmission and refrigeration system performance. The refrigeration system's efficacy is increased by the advantages of reduced expenses, extended system life, and increased heat transfer rates. For HFO blended nano refrigerant performance evaluation, the first law efficiency analyses were performed using nano mixed-based fluid—properties of thermodynamics and energy consumption. By adding nanoparticles to refrigerants improves the thermal performance due to increase in heat transfer coefficient of the refrigeration system while using less electrical energy. This work led to the following conclusions. The coefficient of performance of refrigeration systems may be increased by adding nanoparticles to the refrigerant. Based on a combination of nanoparticles, fluid enhances the first law performances of VCR systems.

- Copper oxide-based nano fluid has the best thermal performance when compared to other nano mixed-based fluids, whereas $TiO_2$ offers the lowest.
- Because nanoparticles combined with glycol increase the COP and evaporator heat transfer coefficient, refrigeration systems using nano-based fluids are more efficient than those without. Heat transfer enhancement in the condenser of a conventional refrigeration system was altered by

nanoparticles, which also had an impact on the thermal performance of the nano-refrigerants.

## References


[1] Mishra, R. S. (2017). Improvements thermodynamic performances of variable compressor speed VCR system using ecofriendly refrigerants. International Journal of Research in Engineering and Innovation, 1(6), 137–142.

[2] Chopra, K., & Mishra, R. S. (2018). Exergy and sustainability investigation of waste heat recovery vapor compression refrigeration system with silver nanofluid. International Journal of Research in Engineering and Innovation, 2(1), 60–66.

[3] Mishra, R. S. (2019). Performance improvement using nanomaterials mixed in R-718 in the secondary circuit of evaporator of VCR system using ecofriendly refrigerants. International Journal of Research in Engineering and Innovation, 3(4), 265–275.

[4] European Parliament and Council of the European Union. (2014). Regulation (EU) No. 517/2014 on fluorinated greenhouse gases and repealing Regulation (EC) No. 842/2006. Official Journal of the European Union.

[5] Yang, M., Zhang, H., Meng, Z., & Qin, Y. (2019). Experimental study on R1234yf/R134a mixture (R513A) as R134a replacement in a domestic refrigerator. Applied Thermal Engineering, 146, 540–547.

[6] Dagidir, K., & Bilen, K. (2024). Usage of R513A as an alternative to R134a in a refrigeration system: An experimental investigation based on the Kigali Amendment. International Journal of Thermofluids, 21, 100582.

[7] Meng, Z., et al. (2022). Research on the application of an HFO1234yf/HFC134a mixture in a vehicle air-conditioner system with an internal heat exchanger. ACS Omega, 7(37), 33138–33146. https://doi.org/10.1021/acsomega.2c03309

[8] Li, W., Liu, R., Wang, D., Shi, J., & Chen, J. (2020). Performance evaluation of R1234yf heat pump system for an electric vehicle in cold climate. International Journal of Refrigeration, 115, 117–125.

[9] Bi, S., Shi, L., & Zhang, L. (2008). Application of nanoparticles in domestic refrigerators. Applied Thermal Engineering, 28(14–15), 1834–1843. https://doi.org/10.1016/j.applthermaleng.2007.11.018

[10] Alagarsamy, S. (2020). Experimental investigation of ZnO/$SiO_2$ hybrid nano-lubricant in R600a VCR system. Materials Today: Proceedings, 45(2). https://doi.org/10.1016/j.matpr.2020.10.180

[11] Baskaran, A., Manikandan, N., Tesfaye, J. L., & Nagaprasad, N. (2022). Investigation on the performance of domestic refrigerator with zirconium oxide-R134a nanorefrigerant. International Journal of Chemical Engineering, 2022, Article 3668458. https://doi.org/10.1155/2022/3668458

[12] Venkataiah, S., & Sthithapragna, G. (2022). Comprehensive evaluation of nanorefrigerants: A review. Materials Today: Proceedings, 72(5). https://doi.org/10.1016/j.matpr.2022.09.094

[13] Gobane, S., Dama, T., Hasan, N., & Yanmaz, E. (2023). Characterization of copper oxide–jatropha oil nanofluid as a secondary refrigerant. Journal of Nanomaterials, 2023. https://doi.org/10.1155/2023/7612959

[14] Said, Z., Rahman, S., & Sohail, M. (2023). Nano-refrigerants and nano-lubricants in refrigeration: Synthesis, mechanisms, applications, and challenges. Applied Thermal Engineering, 233, 121211.

[15] Mishra, R. S. (2020). Methods for enhancing energetic-exergetic performances of VCR system using HFO-1336mzz(Z) refrigerant through nanomaterials mixed with R-718 fluid in secondary circuit of evaporator. International Journal of Advance Research and Innovation, 4(3), 143–148.

[16] Mahbubul, I. M., Fadhilah, S. A., Saidur, R., Leong, K. Y., & Amalina, M. A. (2013). Thermophysical properties and heat transfer performance of $Al_2O_3$/R-134a nanorefrigerants. International Journal of Heat and Mass Transfer, 57, 100–108.

[17] Mishra, R. S., & Jaiswal, R. (2017). Thermophysical property of nanorefrigerant: Preparation, thermal characteristics, and applications. International Journal of Research in Engineering and Innovation, 1(3), 163–170.

[18] Mishra, R. S. (2019). Modelling of VCR system (VCRS) by using alternative refrigerants with CuO and without nanomaterials. International Journal of Research in Engineering and Innovation, 3(1), 36–41.

[19] Mishra, R. S., & Jaiswal, R. K. (2019). Thermal performance improvements of VCR system using eco-friendly based nanorefrigerants in primary circuit. International Journal of Advance Research and Innovation, 3(3), 524–535.

[20] Mishra, R. S. (2020). Methods for enhancing energetic-exergetic performances of VCR system using HFO-1336mzz(Z) refrigerant through nanomaterials mixed with R-718 fluid in secondary circuit of evaporator. International Journal of Advance Research and Innovation, 4(3), 143–148.


**Cite this article as:** Radhey Shyam Mishra, Performance enhancement of VCR using a water condenser using HFO blended Refrigerants with nano fluids in the secondary circuit of the evaporator, International Journal of Research in Engineering and Innovation, 10 (3), (2026), 95-99. *https://doi.org/10.36037/IJREI.2026.10302*.