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Environmental Engineering (EE); Requirements and use cases of liquid cooling and high energy efficiency solutions for 5G BBU in C-RAN mode

Reference

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Keywords

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI Membership Approval Procedure.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

Liquid cooling systems are mainly used for processing capability of the high thermal power density, which exceeds the physical limits of air cooling methods, to support more and more application scenarios where manufacturers are creating competitive advantages. Liquid cooling can provide heat transfer capabilities several orders of magnitude higher than that of air cooling, and applications dealing with high heat density in the core and edge computing as well as access network will increasingly require the support of liquid cooling technology.

The present document identifies the requirements for liquid cooling and high energy efficiency solutions for 5G BBU in Centralized-RAN mode, including requirements of immersion and spray liquid cooling technology, key indicators of immersion and spray liquid, safety requirements of immersion and spray liquid cooling system, management procedure and energy efficiency measurement method, and use cases of liquid cooling solutions.

Introduction

The power consumption of 5G BBU increases significantly compared with that of 4G BBU. On the one side, in Centralized-RAN mode, BBU is centrally installed in the cabinet, and the number of BBU in one cabinet can reach as many as 10. Besides, in the air cooling system of the BBU, the airflow goes in from the left side and out from the right side (or in from the right side and out from the left side). All of the factors mentioned above make it difficult to dissipate the heat generated from BBU, resulting in a significant increase in air conditioning cooling capacity and power consumption required for heat dissipation of BBU equipment compared with the 4G one. On the other side, the internal stability of the equipment becomes poor and the failure rate increases because the internal temperature of the BBU is too high. From the perspective of equipment safety as well as energy saving and carbon reduction, exploring more efficient and energy-saving technical methods is crucial. In order to solve the heat dissipation problem of 5G BBU in Centralized-RAN mode, it is necessary to introduce liquid cooling technology to provide a better heat dissipation effect for equipment with high power density and complex airflow conditions.

Liquids have a much larger thermal capacity than that of gases, which makes them ideal as heat dissipation media in high-density devices, and therefore liquid cooling has been already heavily used in the server cooling of data centres. In the liquid cooling system, there is no compressor, instead, it can directly use the heat dissipation of outdoor air as a natural cold source. The CoolEff of the liquid cooling server has been proved to be reduced to 1.1-1.2 practically. Though the entire power of BBU is less than that of the server, the volume power density is higher compared with that of the server, which makes it suitable to utilize liquid cooling. This recommendation focuses on the solution of liquid cooling method being used in the 5G BBU.

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5. It is published respectively by ITU and ETSI as Recommendation ITU-T L.1326 [i.1] and ETSI ES 203 997 (the present document), which are technically-equivalent.

1 Scope

The present document provides requirements for liquid cooling and high energy efficiency solutions for 5G BBU in Centralized RAN mode (C-RAN), including: requirements of immersion and spray liquid cooling technology, key indicators of immersion and spray liquid, safety requirements of immersion and spray liquid cooling system, management procedure and energy efficiency measurement method, and use cases of cooling solutions.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-T L.1326 (08/2023): "Requirements and use cases of liquid cooling solutions and high energy efficiency solutions for 5G BBU in Centralized-RAN mode".

[i.2] ETSI TS 103 586: "Environmental Engineering (EE); Liquid cooling solutions for Information and Communication Technology (ICT) infrastructure equipment".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

Cloud RAN (C-RAN): Radio Access Network (RAN) where functions are partially or completely centralized, with two additional key features: pooling of baseband/hardware resources, and virtualization through general-purpose processors

Distributed RAN (D-RAN): network development where Radio Access Network (RAN) processing is fully performed at the site, as in 4G

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

4G	fourth Generation
5G	fifth Generation
AHU	Air Handling Unit
BBU	BaseBand Unit
CDU	Coolant Distribution Unit
CoolEff	Cooling Effectiveness
CPU	Central Processing Unit
CRAC	Computer Room Air Conditioner
GSM	Global System for Mobile communications
GTMU	GSM Transmission & Timing & Management Unit
GWP	Global Warming Potential
ICT	Information and Communications Technology
IT	Information Technology
ODP	Ozone Depletion Potential
PCB	Printed Circuit Board
RAN	Radio Access Network
UPEU	Universal Power and Environment interface Unit
UPS	Uninterruptible Power Supply

4 Description of the cooling solutions

In the past few years, the air cooling system makes it possible to accommodate higher heat density cooling requirements by bringing the cold source closer to the heat source or by hot-aisle/cold-aisle containment. However, as rack power density increases to above 20 kW (Figure 1), the benefits of these methods gradually diminish. A variety of liquid cooling technologies have emerged to meet the cooling requirements of high heat density cabinets.

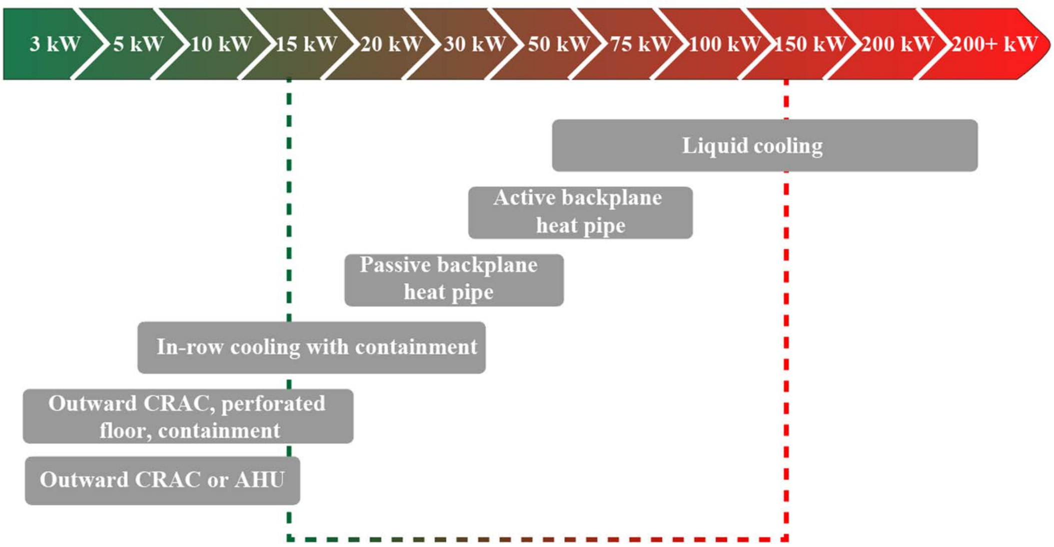

Figure 1: Rack power density and cooling solutions

5G BBU is deployed in the cabinet in Centralized-RAN mode, which not only has a large total power (10 BBUs reach 5-6 kW), but also because the BBU air flow sometimes is insufficient, which makes it difficult to cool the cabinet.

The traditional cooling mode in data centre is not suitable for the cooling demand of 5G BBU in Centralized-RAN mode. The BBU equipment with liquid spray can cool the BBU chip/board with high density and the main board without relying on any air flow channel.

Using immersion and spray liquid cooling technology can not only solve the problem of low energy efficiency for 5G base station (BBU centralized deployment-the C-RAN mode), but also solve the problem of high density of BBU chip and difficulty of heat dissipation. However, as a new technology completely different from the traditional air cooling technology, it needs a complete system design and safety protection mechanism; otherwise unexpected safety risks may appear and damage the whole system.

5 Immersion and spray liquid cooling technology

5.0 General

Nowadays, there are three main types of liquid cooling technology for ICT equipment, i.e. liquid cooling of cold plates, immersion, and spray. The configuration of different parts in 5G BBU is extremely dense and the overall dimension of the 5G BBU device is 2 u high, containing 4 layers of BBU board with each board about 2 cm thick, and the gap between one board and the other is not more than 5 mm. The typical configuration of the BBU is shown in Figure 2. The corresponding slots of the BBU are listed in Table 1. And therefore neither pasting the heat exchange plate on the heat-generating chip of the board nor adding liquid flow copper tubes on the PCB board is feasible. Based on the factors mentioned above, the 5G BBU can only utilize immersion or spray liquid cooling methods other than cold plate liquid cooling.

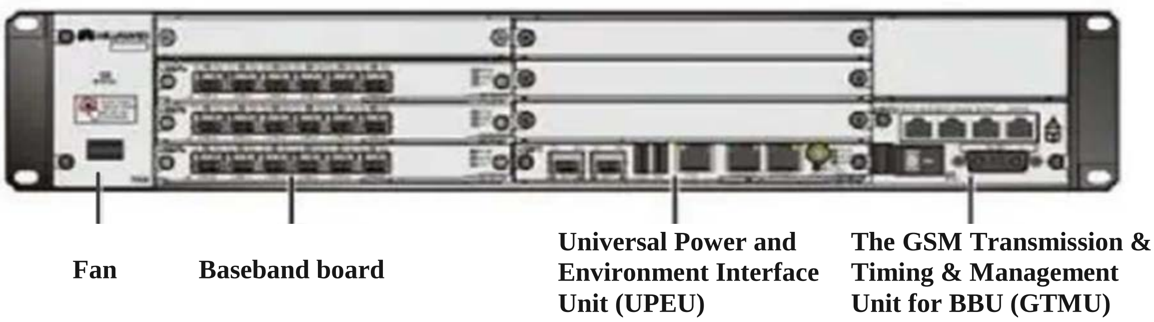

Figure 2: Typical Configuration of the BBU

Table 1: Slots of the BBU

FAN	Slot 0	Slot 4	Power
	Slot 1	Slot 5	
	Slot 2	Slot 6	Power
	Slot 3 (Baseband board)	Slot 7	

5.1 Immersion liquid cooling

In an immersion liquid cooling solution, all BBU components are immersed in a flowing thermally conductive and electrically insulating liquid. By this method, the flowing liquid takes away the heat generated by all BBU components, which maximizes the heat conduction characteristics of the coolant and is the most energy-efficient liquid cooling method. In a single-phase immersion liquid cooling system, the entire BBU device is installed vertically with the front side up in the thermally conductive and electrically insulating coolant. The coolant is in direct contact with all BBU components and absorbs heat from them, after which the coolant is carried by a pump to a heat exchanger in the CDU (coolant distribution unit). Inside the heat exchanger, the heat is transferred between the refrigerant and the coolant resulting in temperature decreases of the coolant, after which the low-temperature coolant can participate in the next circulation of heat absorption of BBU components and heat release in the heat exchanger in the CDU. As for the heat absorbed by the refrigerant, it can finally be taken to the outdoor heat dissipation equipment through the heat exchanger in the CDU. The detailed coolant circulation and heat transfer in single-phase immersion liquid cooling systems are demonstrated in Figure 3. CDU is usually installed near the BBU device cabinet or outside the data centre room.

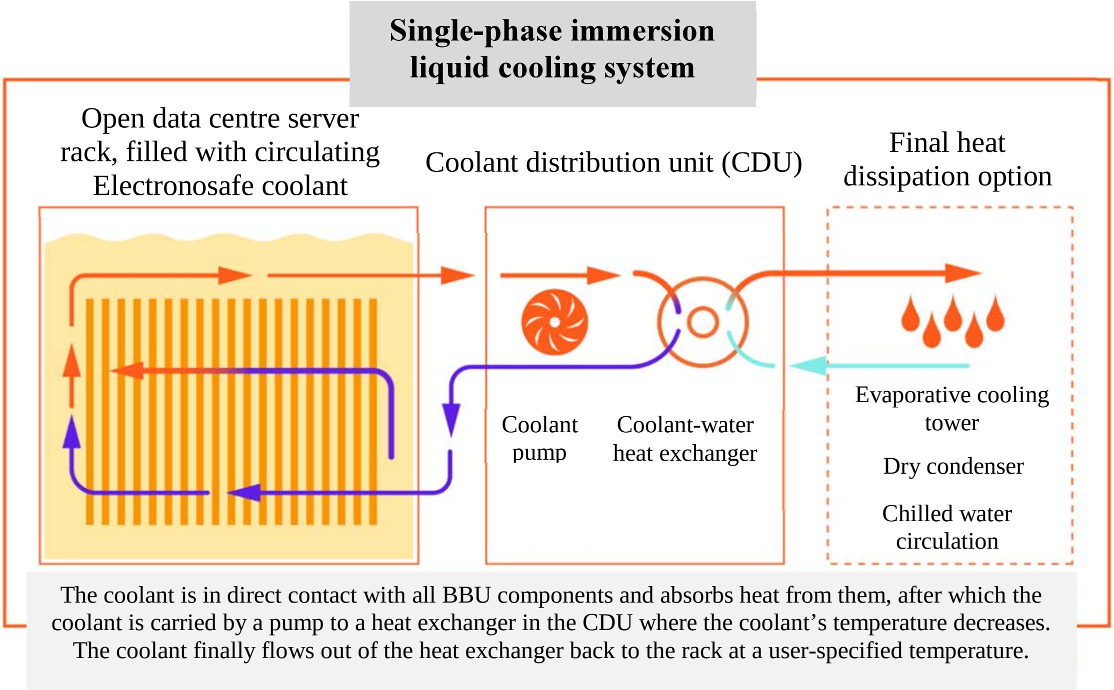

Figure 3: Coolant circulation and heat transfer in single-phase immersion liquid cooling systems

An image of the immersion liquid cooling cabinet is presented in Figure 4. Immersion liquid cooling cabinets usually use horizontal sink cabinets with one cabinet holding 10 BBU devices, and each BBU device holds 6 baseband boards at most. When immersion liquid cooling is used, the fan module of BBU can be saved. In order to facilitate the usual installation and maintenance of BBU devices, all the BBU devices are inserted vertically and the front panel faces upwards and is exposed above the liquid level (some components of the front panel are expected to be in the liquid), so that the upper half of the optical module on the front panel is not soaked in the liquid, minimizing the risk of contamination of the surfaces of the optical module core plug by the liquid. Most immersion liquid cooling uses single-phase fluorinated liquids, which are liquid phases both in the endothermic and exothermic processes, with extremely small liquid volatilization, and there is no need to consider the sealing property of the horizontal cabinet, and the disadvantage is that the heat dissipation capacity is not as much as the gas-liquid phase.

There are several important parameters of the immersion liquid cooling BBU devices to be considered, including overall dimensions, inside dimension of the liquid storage reservoir, available space, the number of BBU devices, BBU device thermal dissipation solution, liquid supply pump redundancy mechanism, maximum heat-dissipation power of one cabinet, cold source, liquid cooling device power supply mode, and annualized CoolEff.

Next, some requirements shall be considered within the important parameters to ensure effective immersion liquid cooling for BBU devices, the requirements are discussed as follows:

a) Overall Dimensions (L×W×H): Specify the required dimensions of the immersion liquid cooling system, including length (L), width (W), and height (H), to ensure compatibility with the designated space and equipment layout.

b) Inside Dimension of the Liquid Storage Reservoir (l×w×h): Determine the dimensions of the liquid storage reservoir, specifying its length (l), width (w), and height (h) to accommodate the required volume of immersion liquid while allowing sufficient space for proper circulation and cooling.

c) Available Space: Assess the available space for installing the immersion liquid cooling system, considering factors such as cabinet layout, equipment placement, and any potential constraints or restrictions.

d) Number of BBU Devices: Determine the total number of BBU devices that need to be cooled using the immersion liquid cooling system to ensure adequate capacity and performance.

e) Liquid Supply Pump Redundancy Mechanism: Implement a redundancy mechanism for the liquid supply pump(s) to ensure uninterrupted cooling in case of pump failure or maintenance requirements. This can involve redundant pumps, backup power supply, or alternative cooling solutions.

f) Maximum Heat-Dissipation Power of One Cabinet: Determine the maximum heat-dissipation power that a single cabinet can handle to ensure the immersion liquid cooling system can effectively dissipate the generated heat from the BBU devices. This information helps determine the cooling capacity required for the system.

g) Cold Source: Identify a reliable and efficient cold source to maintain the immersion liquid at the desired temperature. This could involve refrigeration units, chillers, or other cooling technologies depending on the scale and requirements of the installation.

h) Liquid Cooling Device Power Supply Mode: Specify the power supply mode for the liquid cooling devices, such as direct electrical connection or the use of an Uninterruptible Power Supply (UPS), to ensure continuous operation and minimize potential downtime.

i) Annualized CoolEff: Assess the annualized Cooling Efficiency of the immersion liquid cooling system, which indicates the system's effectiveness in cooling the BBU devices while optimizing energy consumption. This parameter helps evaluate the overall efficiency and sustainability of the cooling solution.

By considering these important parameters, effective design, installation, and operation of an immersion liquid cooling system for BBU devices can be ensured.

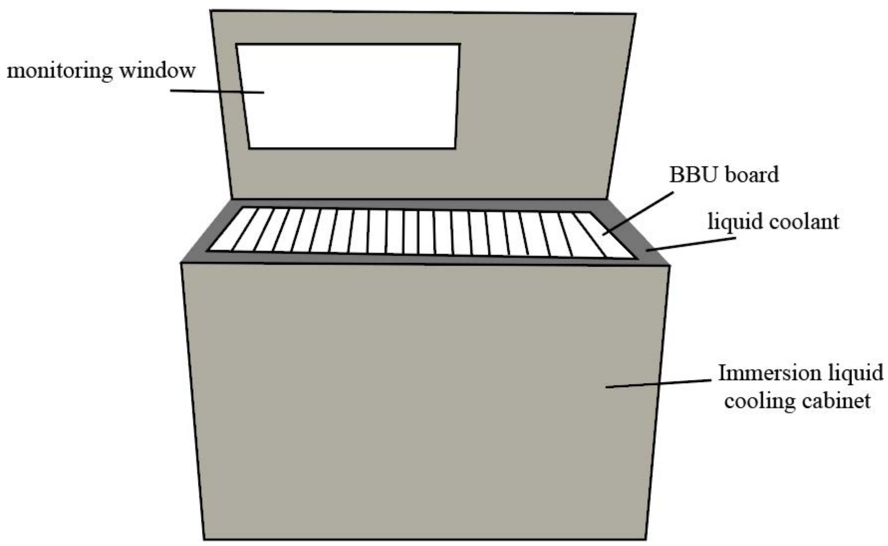

Figure 4: An image of the immersion liquid cooling cabinet

5.2 Spray liquid cooling

The spray liquid cooling method uses a specific thermally conductive and electrically insulating working liquid. By the direct sprinkler, the working liquid is sprayed downwards on the heat-generating components of BBU devices. In this way, the liquid is in direct contact with the heat-generating components, and meanwhile the liquid flows downwards to contact with the heat-generating components in the lower part, which makes it possible to meet the heat dissipation requirements of the entire device. In the one BBU device, there are four layers of boards. When considering the Distributed-RAN mode, all BBU devices are installed horizontally which means four layers of boards pile up on one another, leading to failing to meet the requirements of liquid flowing downwards in the spray cooling system. Therefore, the BBU shall also be installed vertically so that the liquid can flow in along the gap between one board and the other. Spray liquid cooling will be specially designed according to the position of the heat-generating components as well as the amount of heat generation of the BBU board so that the coolant can achieve accurate spraying from top to bottom to ensure the heat dissipation effect and the safety of electronic components. The detailed implementation scheme of the BBU spray liquid cooling system is shown in Figure 5. An ingenious design scheme is to use the existing air inlet and outlet of the BBU cabinet as the liquid flowing channels. In order to allow the coolant to be accurately sprayed according to the position of the heat-generating components as well as the amount of heat generated by the BBU board, the fan module (which is useless) of the BBU device is unplugged and is replaced with the liquid spray distribution slot of the BBU device board as shown in Figure 6.

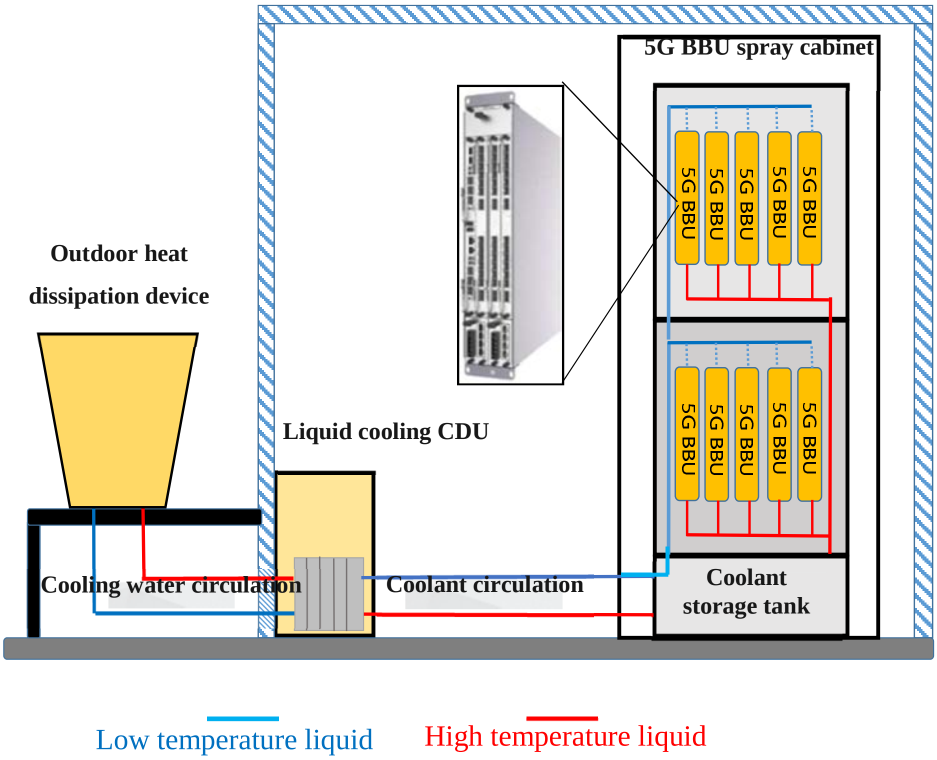

Figure 5: Detailed implementation scheme of BBU spray liquid cooling system

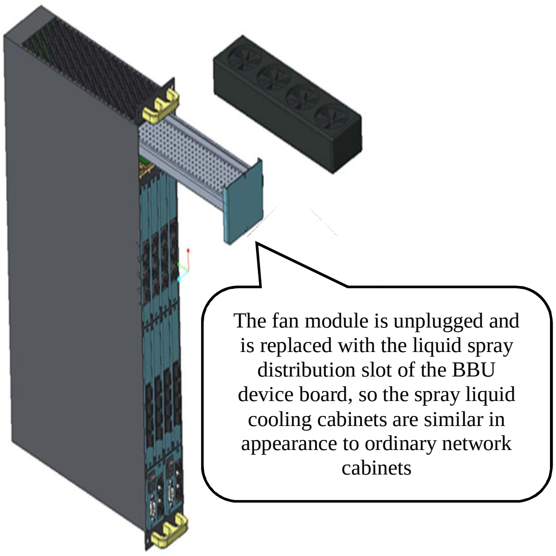

Figure 6: The spray liquid cooling cabinet

Spray liquid cooling cabinets are similar in appearance to ordinary network cabinets but are very different on the inside configuration. The spray liquid cooling cabinet shall take into account the risk of liquid leakage outward when sprayed on the BBU, so the BBU device is integrated and installed on a shelf with a sealed gate. As shown in Figure 7, a cabinet is provided with 2 sub-shelves, each sub-shelf can accommodate 5 vertical BBU devices, that is, a liquid cooling cabinet can carry 10 BBU devices, and each BBU device can hold up to 6 baseband boards.

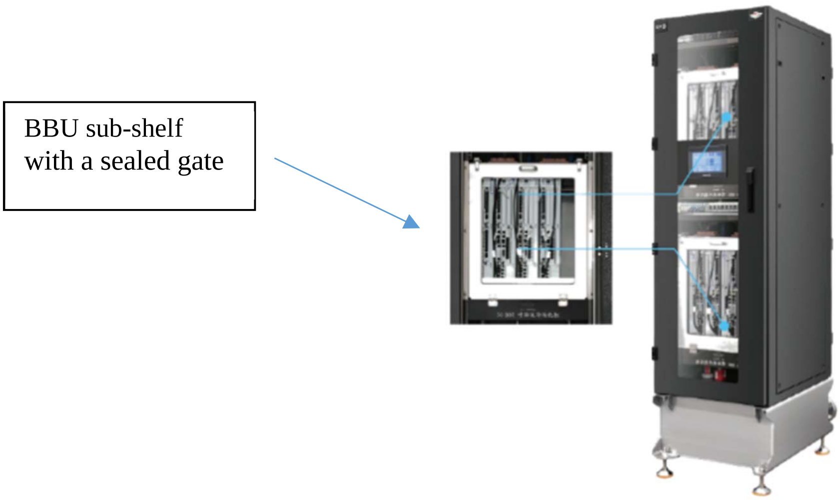

Figure 7: The internal construction of the BBU cabinet

BBU spray liquid cooling system commonly uses silicone oil compounds as coolant, whose viscosity is high and it is easy to form residues on the surface of the equipment, leading to the reduction of the contact area. This also causes the required driving force to be larger than the fluorinated liquid, so the working efficiency is slightly lower than the immersion liquid cooling.

Similar to immersion liquid cooling system, there are also several important parameters of the spray liquid cooling BBU devices to be considered, including overall dimensions (L×W×H), inside dimension of the sub-shelf (l×w×h), available space in the sub-shelf, the number of BBU devices, BBU device thermal dissipation solution, liquid supply pump redundancy mechanism, maximum heat-dissipation power of one cabinet, cold source, liquid cooling device power supply mode, annualized CoolEff and so on. Details can be found in clause 5.1.

5.3 Other liquid cooling technologies

Further liquid cooling technologies, complementary to the immersion and spray ones specified in the present document, can be found in ETSI TS 103 586 [i.2].

6 Key indicators of immersion and spray liquid cooling system

6.1 Requirements of the Liquid coolant

6.1.0 General

The liquid coolant used in the liquid cooling 5G BBU equipment shall meet the following requirements.

6.1.1 Requirements of the equipment operation

For immersion or spray liquid cooling, the liquid coolant shall not affect the signal integrity, power supply and normal operation of the 5G BBU equipment.

6.1.2 Requirements of the physical properties

a) Appearance and odour.

b) The appearance of the liquid coolant is required to be colourless and transparent, and the coolant should be odourless (not including benzene).

c) Viscosity.

d) The kinematic viscosity of the liquid shall be low within the range of the operating temperature of the equipment.

e) Stable electric insulation: The liquid coolant shall have stable electric insulation properties with high volume resistivity, and low dielectric constant. Typical liquid coolant with stable electric insulation properties includes mineral oil, silicone oil, fluorocarbon liquids, and so on.

f) Thermodynamic properties: The liquid coolant shall have good thermodynamic properties, that is, it has relatively high thermal conductivity, high specific heat, and low viscosity. The liquid coolant shall maintain good thermodynamic stability at operating temperatures within the 5G BBU equipment life cycle.

6.1.3 Requirements of chemical properties

The liquid coolant itself does not react chemically with any materials that may come into contact with it (such as all components of the electronic system and structural containers, etc.) which may cause the liquid to decompose; the liquid coolant shall maintain good chemical stability at operating temperatures within the 5G BBU equipment life cycle.

6.1.4 Requirements of safety

The liquid coolant shall have a high flash point and a high auto-ignition temperature and shall be non-corrosive and non-toxic.

6.1.5 Requirements of environmental protection

The liquid coolant shall have zero Ozone Depletion Potential (ODP), low Global Warming Potential (GWP), and low volatility.

6.1.6 Requirements of liquid disposal

Waste liquid coolant shall be collected and disposed of according to local regulations and shall not be discharged directly.

6.1.7 Requirements of control and monitoring

The liquid coolant shall appropriate control and monitoring, i.e. detecting and maintaining important parameters such as cleanliness, pH value, electric conductivity, and so on.

6.2 Requirements of other key indicators

When using the liquid cooling solution of 5G BBU, several applicable precautions and directions shall be followed:

a) Before using liquid cooling, the compatibility test of 5G BBU equipment components, power supply and signal wire materials, optical modules, etc. shall be conducted. Tests for 5G BBU equipment transmission signal integrity shall be carried out.

b) 5G BBU equipment shall have measures for leakage detection, and liquid leakage collection and isolation.

c) The corresponding explosion-proof facilities and system safety monitoring measures shall be configured in accordance with the relevant fire protection requirements.

d) Corresponding monitoring and liquid filtration measures shall be configured with respect to the toxic effects of decomposition products generated under harsh conditions (such as overheating, combustion, etc.).

e) The liquid cooling system shall have a fault detection function to monitor the pressure, temperature, flow rate, and liquid leakage. Once the monitored parameters deviate from the set value, there should be alarms, operating parameter records, and emergency treatment measures.

f) In either immersion or spray cooling system, the liquid is in direct contact with all components of the BBU, and for both of the systems the optical module shall be hermetically sealed and anti-permeable to avoid liquid flowing into the surfaces of the optical module core plug and causing optical power attenuation.

7 Management procedure and energy efficiency measurement method

7.1 Management procedure

To start, the management procedure for liquid cooling solutions for 5G BBU in Centralized-RAN mode involves the following steps:

a) Regular inspection and maintenance of the cooling system to ensure it is functioning optimally.

b) Monitoring of the cooling system's performance to detect any abnormalities or inefficiencies.

c) Prompt repair or replacement of any faulty or damaged components of the cooling system.

d) Regular cleaning of the cooling system to prevent blockages or build-up of dirt and debris.

e) Implementation of energy-efficient practices to reduce the overall energy consumption of the cooling system.

As for the energy efficiency measurement method for liquid cooling solutions for 5G BBU, the following factors shall be considered:

a) The cooling system's power consumption in relation to its cooling capacity.

b) The efficiency of the cooling system's components, such as the heat exchanger and pump.

c) The temperature differential between the coolant and the ambient air or water.

d) The airflow and water flow rate through the cooling system.

e) The cooling system's reliability and durability.

High energy efficiency solutions for 5G BBU in Centralized-RAN mode can be achieved by implementing the following measures:

a) Use of high-efficiency power supplies and components in the BBU.

b) Use of high-efficiency cooling systems, such as liquid cooling.

c) Implementation of software and hardware optimizations to reduce power consumption.

d) Regular maintenance and cleaning of the BBU to ensure optimal performance.

e) Utilization of renewable energy sources, such as solar or wind power, to power the BBU and cooling system.

7.2 Partial Energy efficiency measurement for BBU liquid cooling system

To measure the partial energy efficiency of a liquid cooling system for a 5G BBU in Centralized-RAN mode, the following approach can be used:

1) Define the system boundary: Determine the boundaries of the system on which the measurement of the energy efficiency shall be performed. This includes the BBU, the liquid cooling system, and any other components that are directly involved in the energy consumption.

2) Measure the energy consumption: Measure the energy consumed by each component within the system boundary. This can be done using energy meters, power analysers, or other measurement devices.

3) Calculate the partial energy efficiency: To calculate the partial energy efficiency, the useful energy output shall be divided by the total energy input. The useful energy output in this case would be the amount of energy used by the BBU to perform its functions, while the total energy input would be the sum of the energy consumed by all the components within the system boundary.

4) Optimize the system: Once the energy consumption has been measured and the partial energy efficiency has been calculated, the areas for improvement and optimization of the system can be accordingly identified. This can involve replacing components with more energy-efficient alternatives or implementing more efficient cooling strategies.

5) Monitor and maintain: Finally, it is important to continuously monitor and maintain the system to ensure that it remains energy efficient over time. Regular maintenance and upgrades can help to ensure that the system is operating at its maximum efficiency and minimize the risk of energy waste.

7.3 Total Energy efficiency measurement including liquid cooling system

For a general situation where liquid cooling and air cooling coexist, it is suggested to calculate the Cooling Effectiveness (CoolEff) with respect to the liquid cooling part, the air cooling part, and the totalCoolEff. Let $\mathrm{pCoolEff}_{\mathrm{liquid}}$ denote the partial Cooling Effectiveness (pCoolEff) of the liquid cooling part, $\mathrm{pCoolEff}_{\mathrm{air}}$ denote the partial Cooling Effectiveness of the air cooling part, and $\mathrm{CoolEff}$ denote the total Cooling Effectiveness. The configuration of the calculation of the CoolEff is shown in Figure 8.

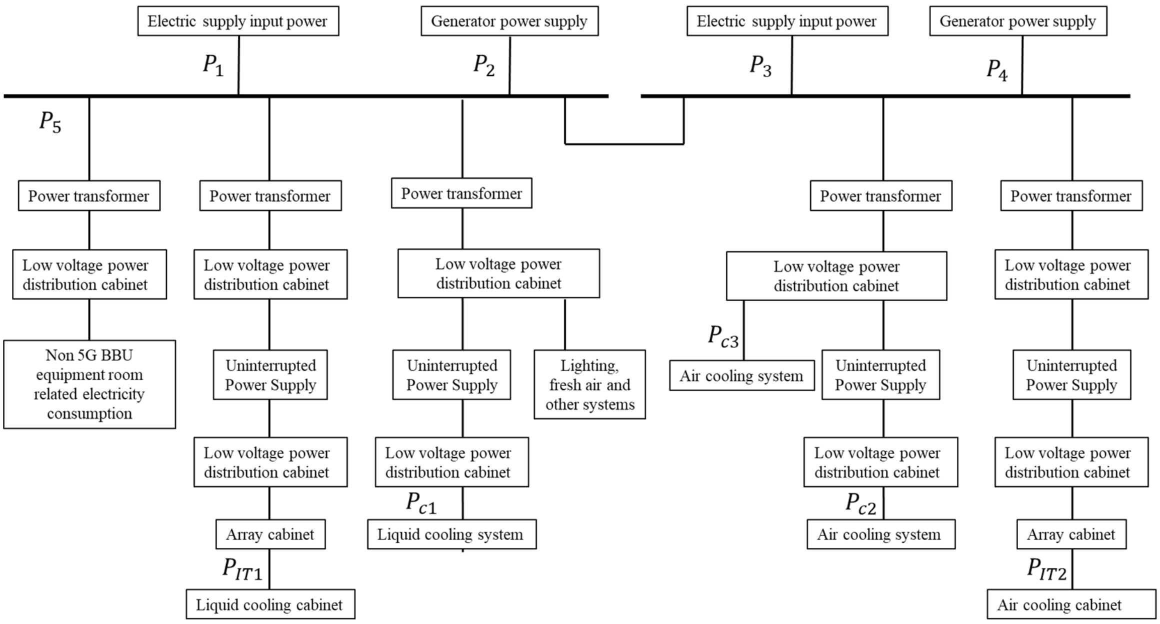

Figure 8: Configuration of calculation of the Cooling Effectiveness ($CoolEff$)

The total power consumption is:

$$\mathrm{P_{total}} = P_1 + P_2 + P_3 + P_4 - P_5.$$

The total IT power consumption of BBUs is:

$$\mathrm{P}_{IT} = P_{IT1} + P_{IT2}.$$

The total cooling system power consumption is:

$$\mathrm{P_c} = P_{c1} + P_{c2} + \mathrm{P_{c3}}.$$

Other power usage of auxiliary systems (including electrical losses) is:

$$\mathrm{P_{other}} = P_{total} - P_{IT} - P_c.$$

Additionally, $\mathrm{P_{other}} = P_{other(liquid)} + P_{other(air)}$ where $P_{other(liquid)}$ and $P_{other(air)}$ are the power usage of auxiliary systems in the liquid cooling part and the air cooling part, respectively.

Then the total $\mathrm{CoolEff}$ reads:

$$\mathrm{CoolEff} = \mathrm{P_{total}}/(P_{IT1} + P_{IT2}).$$

The total power consumption of the liquid cooling part is:

$$\mathrm{P_{total(liquid)}} = P_{IT1} + P_{c1} + P_{other(liquid)},$$

Therefore:

$$\mathrm{pCoolEff_{liquid}} = \mathrm{P_{total(liquid)}}/P_{IT1}.$$

The total power consumption of the air cooling part is

$$\mathrm{P_{total(air)}} = P_{IT2} + P_{c2} + P_{c3} + P_{other(air)},$$

Similarly:

$$\mathrm{pCoolEff_{air}} = \mathrm{P_{total(air)}}/P_{IT2}.$$

When the detailed power usage of auxiliary systems (including electrical losses) for the liquid cooling part and air cooling part is difficult to obtain, a rough calculation can be made by apportioning the proportion of power as follows:

$$P_{other(liquid)} = P_{other} \times P_{IT1}/(P_{IT1} + P_{IT2}),$$

$$P_{other(air)} = P_{other} \times P_{IT2}/(P_{IT1} + P_{IT2}).$$

Annex A (informative): Comparison between liquid cooling and air cooling

Liquid cooling solution has both the advantages of strong cooling capacity and fast heat dissipation in case of complex internal structures, and furthermore it can solve the cooling of high-density server cabinets. The current power of the deployed liquid cooling cabinet has reached 30 kW with some even up to 50 kW. It is the removal of the work caused by the compressor that makes the liquid cooling solution energy efficient.

The liquid cooling can provide the following benefits:

- **Better IT Reliability and Performance**

  Liquid cooling systems can not only achieve the required reliability, but they can also increase the benefits of BBU performance. As the chip enclosure temperature approaches the maximum safe operating temperature, which can occur with air cooling systems, its performance is affected and thus is suppressed, and this can be avoided with liquid cooling systems. Besides, the chip works in a lower–temperature and more comfortable environment, leading to a reduction of the power consumption itself, which is also an energy-saving effect of the liquid cooling.

- **Higher energy efficiency**

  Compared with air cooling, liquids have higher thermal conductivity and liquid cooling does not need fans to drive the airflow between telecommunication rooms and BBU, resulting in significant energy savings in telecommunication rooms with liquid cooling systems. The circulating pump required for liquid cooling consumes less power than that required to achieve the same cooling effect utilizing a fan and a compressor.

- **Sustainability**

  Liquid cooling not only creates opportunities to reduce telecommunication room energy consumption but also reduces electrical CoolEff to a value that is close to 1,0, which provides a more efficient method for heat recovery from telecommunication rooms, all of which can thereby reduce the need for building heating systems. The return water temperature from the liquid cooling system can reach 140° F (60 °C) or even higher, and the liquid-to-liquid heat transfer efficiency is higher than the efficiency that the air system may achieve.

- **Maximizing the space utilization**

  Deployment of high-density cabinets utilizing liquid cooling enables better use of existing telecommunication room space without the need for expansion or new construction, and this type of deployment makes it possible to build facilities with a smaller building footprint. Furthermore, it can also support processing-intensive edge computing applications with limited physical space.

A numerical comparison between liquid cooling and air cooling is shown in Table A.1.

Table A.1: Comparison between liquid cooling and air cooling

Cooling mode	Outdoor primary side heat transfer medium	Indoor secondary side heat transfer medium	Inlet temperature of the refrigerant	Temperature of the chip surface	Cooling effects
Liquid cooling	Cooling water: 32 °C / 37 °C	Coolant: 43 °C / 38 °C	43 °C	60 °C to 70 °C	Liquid cooling not only saves energy, but also the temperature of the heat-generating component is lower with less power consumption and a longer life.
Air cooling	Cooling water: 32 °C / 37 °C	Chilling water: 12 °C / 7 °C	26 °C	70 °C to 80 °C	

Annex B (informative): On-line monitor function of the liquid cooling system

The liquid cooling system should have an on-line monitor function for the important operating parameters, such as pressure, temperature, flow rate, and liquid leakage.

Examples of monitoring functions for the operating temperatures are shown in Figure B.1.

Figure B.1 shows the temperature changes of its main heat-generating components (i.e. CPU) and the ambient in the long-term operation of BBU.

The on-line monitor function of the liquid cooling system is important in two aspects, firstly, real-time monitoring of operation data supports fault detection in time and providing alarm, so as to ensure the safe and stable operation of the equipment; secondly, the collection and storage of monitoring data can provide a data basis for offline analysis, e.g. analysing the power consumption efficiency.

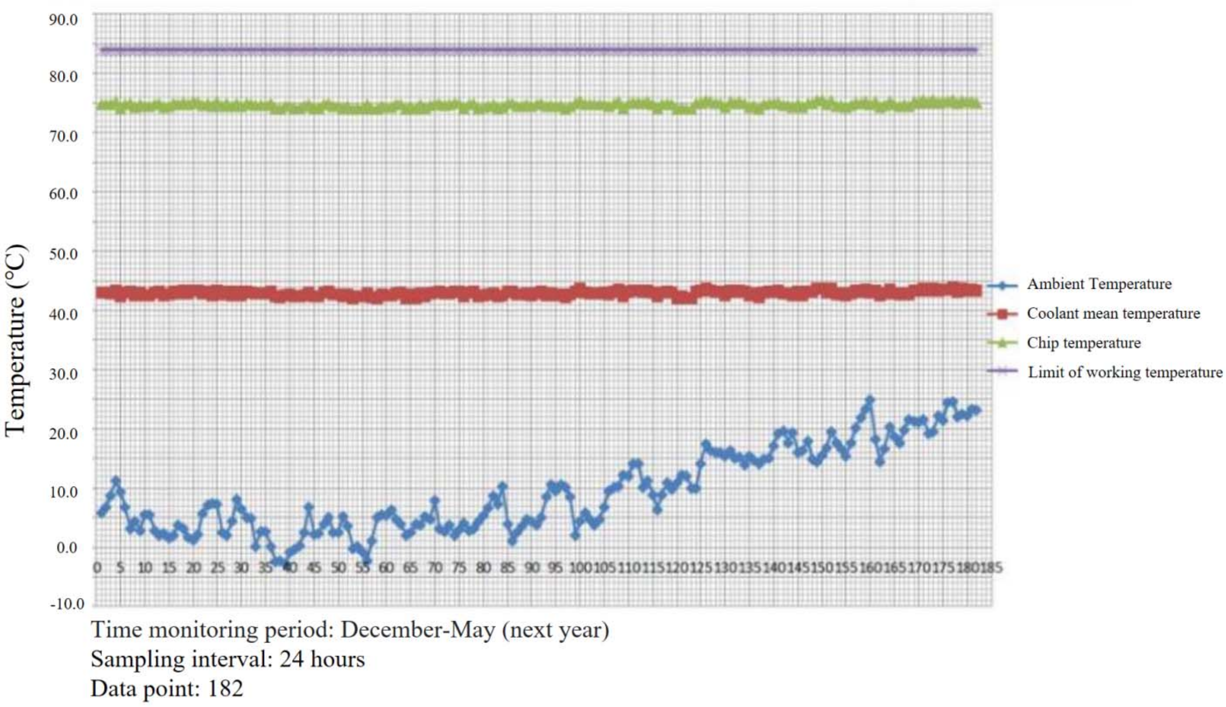

Figure B.1: Temperature series

Annex C (informative): Bibliography

- ETSI ES 203 700 (V1.1.1): "Environmental Engineering (EE); Sustainable power feeding solutions for 5G network".
- Recommendation ITU-T L.1210 (12/2019): "Sustainable power-feeding solutions for 5G networks".

History

Document history		
V1.1.0	February 2024	Membership Approval Procedure MV 20240426: 2024-02-26 to 2024-04-26